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Exploring student agency during the shift to collaborative contributors in small-group argumentation activity in middle school science classrooms

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Abstract

In science education, scientific argumentation has been highlighted as a core epistemic practice of the scientific community. To support students' positioning in the center of knowledge development in argumentation activities, it has been asserted that students need to shift from the perception that teachers alone possess "scientific" knowledge. Based on the notion that students' perceptions dynamically shift in a context-sensitive manner, previous studies with a framing perspective have explored the contexts that facilitate students' productive framing, that is, students' framing of classroom activity, wherein they are expected to and allowed to participate as contributors in the construction of knowledge.

However, we still lack an understanding not only of how students frame themselves as contributors in the construction of knowledge but also of how they acknowledge one another as collaborative contributors during this shift in framing. This study aimed to explore this aspect based on students' interactions in argumentation activities and focused on student agency as a main feature facilitating the negotiation of group members' framing of their positions in argumentation activities in science classrooms. Specifically, I first conducted a theoretical investigation on student agency to develop a framework for the analysis of student agency that facilitates a shift in group members' shared framing. Then, based on this theoretical investigation, two case studies were conducted. The first case focused on a small group of students who acknowledged one another as collaborative contributors in the development of a communal argument through group discussion. This case demonstrated how student agency plays an essential role in facilitating a shift in students' shared framing of their positions as collaborative contributors. The

second case study explored a small group of students with a marginalized student. This study identified the marginalized student's various attempts to be accepted as a contributor by the other students, facilitating the negotiation of the framing of argumentation activities. The findings of these studies can contribute to our understanding of the role of student agency in the construction of a collaborative learning community in science classrooms.

In the theoretical investigation of student agency, I explored which aspects of student agency have been studied previously and the ways in which agent practices in learning communities have been investigated. The results of the investigation revealed five aspects of agency related to students' actions in a learning community: epistemic agency, transformative agency, educated action in science, disciplinary agency, and material agency. I also delineated the three approaches by which the previous research has examined the practices of students as agents who construct learning communities. These approaches are as follows: (a) describing agency as a whole across the entire learning community, (b) describing the influence of a focused student's agency, and (c) describing interactions between agents. Based on these analyses, I developed an approach to discuss student agency in terms of the student's capability to facilitate the negotiation of framing and the way in which students negotiated the framing of the argumentation activity in subsequent discussion.

Based on this theoretical investigation of student agency, two case studies were conducted. In both cases, the argumentation activities were designed to facilitate the students' framing of the argumentation activity as a process of collaborative knowledge construction and implemented in science classrooms. In the first case study, I focused on the group that clearly showed a shift toward productive

framing, that is, students' engagement in discussion for the development of a communal argument. Then, I investigated how the students negotiated the personal framings of their positions and how this negotiation of framing was facilitated in the group. The analysis showed that the focus group's interactions were initially focused on the student with higher epistemic authority. One student facilitated changes in this interaction pattern. She was able to initiate the changes by forming a zone of interaction separate from the student with higher epistemic authority. She facilitated the negotiation of framing, and the students shifted to framing one another as collaborative contributors through their interactions. Later, in the collective zone of interaction with all group members, the students began to justify their claims with their own ideas, sharing positional framing of themselves and one another as collaborative contributors. These findings suggest that the context that has been discussed as facilitating students' active participation can be more precisely described as facilitating the beginning of students' negotiation of positional framings. Students' shared framing of themselves and each other as collaborative contributors manifested after the negotiation of their personal positional framings that was facilitated by a student's agency.

In the second case study, I focused on a group with a student who was marginalized in the group and was not accepted by the other students in group discussion. I identified the discursive moves that reflected this student's agency in his attempts to position himself as a collaborative contributor in small-group argumentation activities. Then, I explored how the structure of the group activity was negotiated in the subsequent discussion. Finally, I discussed how argumentation activity in a science classroom affected students' negotiation of the activity structure. The student's agentic discursive practices were categorized as "presenting reasoning

based on cognitive resources," "presenting the epistemological framing of the argumentation activity," or "presenting a reflection on previous epistemic practices." The students' negotiation of group activities in the subsequent discursive interactions varied with their varying positional framings of the marginalized student and power relations. The discussions subsequent to his discursive moves revealed that the other students perceived that he did not possess a valid epistemological understanding or valid cognitive resources that could contribute to the process of constructing communal knowledge claims. The contexts in which his ideas were addressed in group discussions were characterized by three features. The first was the rebuttal of an idea presented by the marginalized student followed by the acknowledgment of its validity. The second was the acknowledgment shown after the marginalized student's justification of the validity of his ideas. In another context, when he asked other students to supplement his understanding with the elaboration of their own ideas—presenting his thoughts as modifiable—he was accepted in the discussion with the other students. Most of the time, the marginalized student's practices and the reasoning he provided were acknowledged when he justified his ideas by stating that they were consistent with scientific concepts or with the epistemic practices of scientific argumentation. Through this process, the students tried to position themselves as authors of knowledge while reflecting on the dialogical features of scientific argumentation.

Based on the findings in these three sub-studies, this dissertation describes that student agency facilitates group members' framing of their positions as collaborative contributors to knowledge development in small-group argumentation activities in science classrooms. Based on the previous literature that has explored instructional supports that can facilitate student framing shifts, this study suggests

that it is not only the instructional supports that facilitate the framing shift; student agency also plays an important role in students' shaping of their discussion into dialogical argumentation. The implication of this study is based on its illustration of student agency in students' shifts to positioning themselves as collaborative contributors, which provides information for understanding and supporting the construction of a collaborative learning community in the context of argumentation activity in science classrooms.

Keywords: agency, framing, positioning, argumentation activity, collaborative contributor, framing negotiation

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Chapter 1. Introduction

There has been a continuous argument for reflecting the scientific community's epistemic culture in science classrooms. One of the main supports for this argument is that in a class that focuses on the delivery of scientific concepts, students could be merely passive receivers of superficial information that is expressed in terms of the scientific community. Thus, the student role deviates from the sociocultural perspective that students should be able to position themselves in the classroom as agents of their own learning. Additionally, this classroom culture leads students to perceive science as merely an accumulation of scientific knowledge and does not address the process by which such knowledge is developed or the culture of the scientific community in which such knowledge is produced. Recently, the traditional teacher-led classroom with a primary focus on scientific concepts has led to an emphasis on students' position as agents in the construction of knowledge and on learning about the culture of the scientific community (e.g., Duschl, 2008; Ministry of Education, 2015; NRC, 2012).

With this argument, the main features of epistemic practices in the scientific community, of which scientific argumentation is one, are delineated. Scientific argumentation is described as a process of justifying and critically refuting a knowledge claim about natural phenomena (Driver, Newton, & Osborne, 2002; Duschl & Osborne, 2002). To get the knowledge they devise to be recognized as knowledge of the scientific community, scientists seek to justify its validity and persuade other community members. Scientific argumentation is the activity that highlights the cognitive and social aspects of this process.

As activity that encourages students to participate in discussion to construct a knowledge claim that is justified based on their cognitive structure, argumentation activity is expected to be able to provide the context for students to position themselves in the center of the development of knowledge through interaction with others. Specifically, in argumentation activities, students are expected to apply their knowledge and construct knowledge claims about various natural phenomena in their own voice rather than simply accepting the knowledge expressed in scientists' terms. In this process, the previous studies have argued that students can develop a more in-depth understanding of scientific concepts (Jiménez-Aleixandre, 2002; Mason, 1998; Von Aufschnaiter, Erduran, Osborne, & Simon, 2008), critical thinking ability (Jiménez-Aleixandre & Puig, 2012; Kuhn & Crowell, 2011; Sampson & Clark, 2009; Osborne, Erduran, & Simon, 2004; Zohar & Nemet, 2002), and communication skills (Chung, Yoo, Kim, Lee, & Zeidler, 2016; Zohar & Nemet, 2002).

However, introducing argumentation activity into the science classroom is not sufficient to shift students' practices. The main reason for this limitation is that the type of instruction that merely transfers knowledge has been fixed in the science classroom for a long time, and students might recognize that argumentation activities will be conducted in the same way (Berland & Hammer, 2012; Berland & McNeill, 2010; McNeill, González-Howard, Katsh-Singer, & Loper, 2017). In other words, if classroom participants expect knowledge to be delivered to them by authoritative sources, they will still try to accept the information from those sources in argumentation activities. In this sense, to support students' position as agents of knowledge development in argumentation activity, it has been argued that students need to shift from the perception that only teachers possess the "right"

knowledge and recognize that they also have the epistemic authority to construct valid knowledge (McNeill, 2011; Stroupe, 2014).

Studies in science education have examined students' understanding of science classes from various perspectives. Much research has viewed students' understanding in terms of developmental stages or beliefs (e.g., King & Kitchener, 2004; Schommer, 1990). Alternatively, it has recently been argued that students' understanding—that is, students' framing of the science classroom—dynamically shifts rather than remaining consistent (Berland & Hammer, 2012; Hutchison & Hammer, 2010; Rosenberg, Hammer, & Phelan, 2006). From this framing perspective, it has been argued that students can understand a classroom activity differently depending on where their attention is focused in the learning environment (Berland & Hammer, 2012; Hutchison & Hammer, 2010). These studies have argued that students can understand a situation differently by paying attention to different aspects of the learning environment. They have also shown that where students focus their attention can dynamically shift as they interact with others, sharing the different ways they frame the activity in which they are situated.

Based on this perspective, the previous studies have explored the contexts or teacher's support that facilitate students' framing of science classroom activities as activities in which they are expected to, and are granted the opportunity to, participate as agents of knowledge construction (Berland & Hammer, 2012; Hutchison & Hammer, 2010; Rosenberg *et al.*, 2006). For example, in the study by Rosenberg and colleagues (2006), the teacher encouraged students to begin with their own ideas to construct an explanation, which worked as a contextual cue facilitating the students to begin developing the explanation in their own words. As in this example, the contextual cues described in such studies that have adopted a

framing perspective validate students' ideas in the sense that the ideas contribute to the process of developing reasonable arguments. Thus, the cues facilitate students' perception of the activities in which they are situated as activities in which the value of their practices is acknowledged, thereby motivating them to actively engage in discussion.

While observing students' epistemic practices in the context of this type of contextual cue, I noticed that there were some students who began to actively participate in discussion, but most of the students still remained in passive positions. There were a few small groups that shifted to collaborative discussion. Even among the groups that shifted to collaborative discussion, for many of them, the shift did not occur as a sudden change. I noticed that there was a process of transferring and negotiating their framings through discussion as they positioned themselves as collaborative contributors to the development of a communal argument. I refined the questions I had developed while observing students' practices as follows. First, how do students not simply shift and frame their roles as contributors to knowledge development but also share that framing with one another? Such cues can lead students to change their epistemic understanding of argumentation activities; however, these cues are unlikely to be interpreted in the same way by all the students simultaneously since there are various possible interpretations of the same situation (Goffman, 1974). Therefore, students may need to negotiate their different framings with one another during interactions in the context of these cues.

Second, how do students enable one another to engage in the development of arguments? In the studies that have explored shifts in students' framing, productive framing was inferred from students' active participation in dialogical

discussion to make sense of natural phenomena. Engaging in collaborative knowledge-making discussions encompasses not only participating as rational agents but also acknowledging one another as rational agents. Specifically, in students' interactions, it is necessary for them not only to propose diverse ideas but also to listen to others' ideas and consider those ideas in their construction of arguments. Considering these aspects, I expected that the contextual cues delineated in the literature would trigger students' intention to actively engage in discussions in which they transfer their framing of their and others' epistemic roles, thus aligning their emergent framings as collaborative contributors. Discourse that aims to make sense of natural phenomena could be developed through students' discussion and students' agency to restructure their own activities.

On the basis of these questions, in this study, I explored student agency as facilitating group members' negotiation of the framing of their positions as collaborative contributors in the development of knowledge in argumentation activities in science classrooms. I think it is important to discuss student agency that facilitates the negotiation of framing because students have more responsibility to shape an argumentation activity when the activity is implemented in a small-group activity format. Small-group activity provides more space for individual students to participate, and a teacher cannot continuously observe and support student participation because discussions in multiple groups proceed simultaneously. Thus, to understand students' shifts to collaborative discussion in this classroom context, I think it is important to explore how student agency facilitates the negotiation of and shift in framing.

Additionally, considering student agency in a shift in framing allows us to understand students as active participants who shape their activities and who do not

merely react to the contextual cues that are given to them. Students' activation of their cognitive ideas is not a sufficient basis to describe them as agents in learning. Furthermore, for students to participate in collaborative discussion, it is necessary for them to realize how epistemic roles need to change and how knowledge can be developed in this new context. With the shared goal of developing a consensual argument, students also need to alter their practices in response to the other students' practices. These features cannot be achieved simply by simple activation of cognitive ideas in response to contextual cues; instead, students need to understand the goal of the given activity, evaluate the current discussion, and appropriately activate the resources that they think are necessary. However, shaping classroom activity used to be the teacher's role in traditional teacher-centered classrooms, which was a strategy that helped teachers hold epistemic authority. Sharing this role can alter the power relations among students and affect students' participation and negotiation of their framing. Thus, to support students' participation as collaborative contributors in argumentation activity, I think it is important to understand student agency as facilitating the shift in their shared framing of the given argumentation activity.

Specifically, I first conducted a theoretical investigation on how agency has been discussed in the context of students' practices in science education literature. Based on these findings, I developed an approach to discuss student agency that facilitated group members' shifting to framing themselves as collaborative contributors in a small-group argumentation activity. Based on the results, I conducted the first case study, in which I explored how student agency can be identified as a key role in facilitating a shift in students' framing of their positions as collaborative contributors in small-group argumentation activities.

Then, in the second case study, I explored how students negotiated their framings in the discussion following a student's agentic discursive moves with the intention to be accepted as a collaborative contributor by the other group members. This study has educational implications for efforts to create a science learning environment that supports students' construction of a collaborative knowledge-developing community.

1.1 Theoretical Framework and Conceptual Definitions of the Terms

1.1.1 Theoretical framework

This study aimed to identify and explore student agency in students' shift to framing their positions as collaborative contributors in the development of communal knowledge in small-group argumentation activities in science classrooms. The hypothesis that student agency plays a key role in facilitating a framing shift to positions as collaborative contributors is based on my observation of students' work in argumentation activities in science classrooms as well as my understanding of the past research on the perspective of framing and the dialectical relationship between structure and agency.

This study is built on the previous studies along the following three main themes: (a) dialogical argumentation in science classroom, (b) student agency, and (c) framing perspective. Detailed reviews of the studies on these themes are presented in Chapter 2. I integrated these themes as shown in Figure 1. To explore these features of students' argumentation activities that facilitates the framing shift during classroom discussions, I have adopted the notion of the dialectical relationship between structure and agency, which explains that the structure of the activity in which participants are engaged is shaped by the participants' practices and that the participants' practices are also afforded and constrained by the structure (Sewell, 1992). Thus, activity structure and participants' agency interact with each other constantly, continuing and reshaping the activity.

In particular, this study focused on the schema of the activity and established the framing perspective as a perspective for exploring the schema of students' small-group argumentation activities. William Sewell (1992) described

two components of structure: resources and schema. I especially focused on schema, which is described as a virtual and generalized construct that can be explained by concrete practices in particular contexts. Sewell also conceptualized structure as having multiple levels and being transposable, opening up the possibility of diverse perceptions of the structure in a particular activity. Moreover, this condition allows various agents to be empowered in the activity. In a small-group activity in which a teacher cannot consistently observe and participate in students' work, this generalized schema is constructed in students' practices and by students themselves. Students' understanding of how and by whom knowledge is constructed in science classrooms affords and constrains their participation pattern. To explore this specific aspect of schema constructed based on students' understanding, I adopted a framing perspective.

Framing is explained as a tacit answer to the question "What is it that's going on here?" (Goffman, 1974, p. 8). Erving Goffman (1974) referred to framing as a "framework of interpretation," which is in line with Sewell's notion of schema. Based on Goffman's work, Deborah Tannen (1993) extended the framing perspective further, making it possible to explore participants' dynamically shifting understanding of an activity during their discussion. In this study, I viewed a small-group argumentation activity in the context of science classroom as providing the general structure of a science classroom activity that the students can frame. In this context, I attempted to investigate the schema of the activity based on the students' understanding of that activity and not on those of the teacher or the instructor. I posited that the way students activate their cognitive resources to develop an argument is afforded and constrained by their framing—specifically, how they expect their knowledge is constructed and what they perceive to be their role in the

argumentation activity. Thus, to explore how students shift and negotiate their understanding of the schema of the group during group discussions, I conducted my investigation from the perspective of framing.

Framing can be explored at two levels: personal framing and shared framing. Students can frame a group activity individually, and their individual framings can differ from one another. This process is called personal framing. Students can also delineate their various personal framings in their discussion as well as negotiate and reach a shared framing. Further, there are different and interrelated aspects of framing that depend on which side of the activity is being framed by the participants. Since this study focuses on students' epistemic practices and their social relationships in small-group argumentation activity, I focused on epistemological and positional framings. Epistemological framing in argumentation activity can be inferred as students' expectation of how knowledge is constructed in a given argumentation activity in science classrooms (Berland & Hammer, 2012). Positional framing refers to individuals' sense of entitlement or expectations of themselves and others in terms of how they participate in interactions (Greeno, 2009; van de Sande & Greeno, 2012).

Student agency is identified in students' discursive practices that facilitate the negotiation of framing in their group in an attempt to be accepted as collaborative contributors (co-contributors) by other group members. This approach is derived from studies on student agency in science education, especially from studies of epistemic agency and their focus on students' contributions to the development of knowledge and knowledge construction. This study is in line with these studies in that argumentation activity is the context that emphasizes enculturation of a scientific community's epistemic practices. I describe student

agency as a student's capability to facilitate the negotiation of framing, which contributes to developing arguments and shaping their group's argumentation activity.

I also focused on studies on transformative agency that have examined student agency from students' practices that shape and restructure science learning activity, with an intention to develop positive identities in science classrooms (e.g., Basu, Barton, Clairmont, & Locke, 2009). These studies have developed this approach based on Sewell's description of agents as "empowered by access to resources of one kind or another" (p. 10). The studies on student agency can be explained as specifically focusing on the moments that facilitate the empowerment of students to gain access to resources for learning activities in science classrooms. I adopted the directivity in the description of agency in this study and examined student agency based on students' attempts to be accepted as co-contributors by other group members. Additionally, I attended to students' empowerment in exercising agency and how it is afforded or constrained by other group members.

To adopt framing theory and structure-agency theory together, I need to explain my perspective on "resources." I focused on the students' cognitive resources as another main feature of the activity that influenced the interplay of agency and framing. The definition of the term "resources" closely approximates the view of Hammer and colleagues (Hammer & Elby, 2002; Hammer, Elby, Scherr, & Redish, 2005; Louca, Elby, Hammer, & Kagey, 2004). They explained that students' conceptions are composed of fine-grained elements and that in a particular context, students activate the cognitive elements that are relevant to the context that they perceive, and they then constitute a certain conception. The activation of these elements can change in relation to the context as students frame

the situation differently. To explore students' participation in argumentation activity with consideration of their framing, I defined resources based on the view of Hammer and colleagues.

This definition of resources can also be explained as possessing the features of social and cultural resources in Sewell's theory. Sewell (1992) followed Giddens's (1979, p. 92) definition of resources as "the media whereby transformative capacity is employed as power in the routine course of social interaction." Sewell's sociological approach to resources is differed from the view of Hammer and colleagues in that Sewell described resources as accumulated labor and as socially recognized and suggested that access to and the appropriation of resources can give people power over others. In this study, I explored students' practices in the context of argumentation activity in which students' participation in the development of validly justified knowledge was valued. Thus, I specifically focused on students' cognitive resources from a cognitive psychological view rather than on their cultural resources from a sociological view. Students' cognitive resources are the media by which the students can participate in interactions with others and produce knowledge (social resources), and the students' activation of such resources is closely related to their capability and epistemic authority as recognized by one another (cultural resources).

Furthermore, I posit that students' different framings can show one part of the schema of their small-group argumentation activity. When one individual's personal framing is more reflected than others' in the negotiation of shared framing, it can alter students' participation pattern and power relations. The possession and activation of cognitive resources is largely altered by the negotiated framing and activation of cognitive resources, which can contribute to the development of

communal argument and is closely related to power relations among the students. These features can be explained with Sewell's assertion (1992) that the schema affects the way in which resources are activated. One participates in an activity through the activation of resources, reproducing and modifying the existing schema. One's resources can be recognized as "resources" because the social schema allows them to be perceived as possessing the potential to affect the social structure. Then, the agent is "empowered by access to resources" (p. 10). This theory can be adopted to explain students' different positions and participation patterns in science classrooms (Varelas, Settlage, & Mensah, 2015). Based on this discussion, I specifically focused on students' cognitive resources and placed student agency and framing in a dialectical relationship.

In this study, the argumentation activities enacted in science classrooms were designed to facilitate the students' position as producers of knowledge. The dialogical features of argumentation are highlighted in the argumentation activities that are enacted in the science classrooms. The dialogical features of argumentation activities highlight that argumentation is an activity in which multiple participants collectively critically evaluate alternative knowledge claims (Ford, 2012; Kuhn, 1991). Furthermore, these dialogical argumentation activities were designed as small-group activities, discussed in the extant studies as an instructional method that provides each student with space to actively participate in the discussion (Bennett, Hogarth, Lubben, Campbell, & Robinson, 2010). As a result, the classroom setting in this study facilitated the students' activation of cognitive resources to develop communal knowledge in a group. In addition, since dialogical argumentation is a social process, it provides space for the students to delineate their existing social relationships and to negotiate their social relationships.

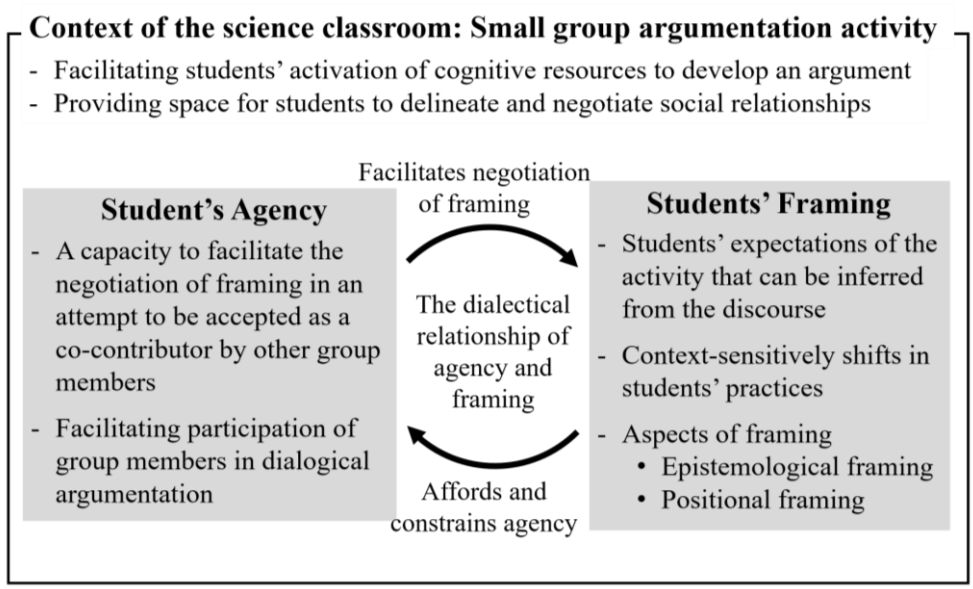


Figure 1. Theoretical framework of this study to explore student agency in students' shifts to a shared framing of themselves as co-contributors in small-group argumentation activity

1.1.2 Conceptual definitions of the terms

The terms in the above theoretical framework and the terms extensively used in this study were defined as below. The definitions of the terms were adapted from the literature or modified in the context of this study.

Small-group argumentation activity

Scientific argumentation is described as a process of justifying and critically evaluating a knowledge claim about natural phenomena (Driver *et al.*, 2002; Duschl & Osborne, 2002). Scientific argumentation is a social process as well as a cognitive process by which the scientific community revises and develops communal knowledge. Argumentation activities have been enacted in the science classroom to provide opportunities for students to be at the center of the process of knowledge construction. This study is in line with this description of argumentation activity that highlights its dialogical features. Additionally, this study explored classrooms in which small-group argumentation activities were enacted to increase each student's opportunity to participate in the interaction (Kang, Lee, & Lee, 2004). In this study, small-group argumentation activity is described as a science classroom context that facilitates students' participation in a process of justifying and critically evaluating a knowledge claim about natural phenomena in a group of four to six students.

Framing

Framing is one of the perspectives used to explain how participants perceive the activity in which they are situated (Bateson, 1972; Goffman, 1974; Tannen, 1993), which is a tacit answer to the question "What is it that's going on

here?" (Goffman, 1974, p. 8). Framing theory highlights that it is difficult to grasp all the elements of an activity in which we are situated; instead, we frame the activity based on previous experience relevant to certain elements of the situation that we have noticed (Tannen, 1993). It is described that people can even frame the same activity in different ways, depending on the aspects of the activity to which they are paying attention, and people's framing can shift if they pay attention to different parts of the activity. Framing theory has been adopted in science education as an approach to explore student understanding from context-dependent shifts in their practices (e.g., Hammer *et al.*, 2005; Hutchison & Hammer, 2010; Russ, Lee, & Sherin, 2012). According to this literature, framing is defined as a participant's expectations of an activity in which they are situated that is implicitly or explicitly transferred to the others through interactions.

Epistemological framing

Epistemological framing is described as a participant's expectations of the knowledge that is to be constructed in an activity and how it is to be constructed (Greeno, 2009; Hutchison & Hammer, 2010; Redish, 2004). Epistemological framing in an argumentation activity can be inferred as students' expectations of how knowledge is constructed in the given argumentation activity in the science classroom (Berland & Hammer, 2012).

Positional framing

Positional framing refers to a participant's expectations of how he or she and the other participants will participate in an activity (Greeno, 2009; van de Sande & Greeno, 2012). Taking a specific position determines one's particular

practices and this position is transferred to others through interaction (Holland, Elby, Scherr, & Redish, 1998). During interactions, students can negotiate and dynamically shift the framings of their positions.

Student agency

In this study, student agency is defined as a student's capacity to facilitate the negotiation of shared framing in one's group in an attempt to frame group members as collaborative contributors in discussion. This approach is derived from studies on epistemic agency and their focus on students' contributions to the development of knowledge and knowledge construction (e.g., Sharma, 2007; Stroupe, 2014). I also focused on studies of transformative agency and the directivity of agency, which is shown in the features of agency in these studies (e.g., Barton & Tan, 2010; Basu *et al.*, 2009). I discussed directivity in the description of agency in this study and examined student agency from a student's practices aimed at positioning oneself as a collaborative contributor to facilitating group members' negotiation of and shift in framing in subsequent discussions.

Cognitive resources

Hammer and colleagues (Hammer & Elby, 2002; Hammer *et al.*, 2005; Louca *et al.* 2004) described that students' conceptions are composed of fine-grained elements and that in a particular context, students activate the cognitive elements that are relevant to the context that they perceive, and they then constitute a certain conception. The activation of these elements can change in relation to the context as students frame the situation differently. To explore students' participation in an argumentation activity with consideration of their framing,

according to Hammer group's view, cognitive resources are described in this study as the finer-grained and manifold elements of students' cognitive structures that are activated to construct and develop knowledge. This definition of resources can also be explained as possessing the features of social and cultural resources in Sewell's theory (1992). Students' cognitive resources are the media by which the students can participate in interactions with one another and produce knowledge (social resources), and the students' activation of such resources is closely related to their capability and epistemic authority as recognized by one another (cultural resources).

Epistemic authority

In this study, epistemic authority is defined as students' recognition of a participant's capability to contribute to the development of knowledge. This definition is in line with Engle and Conant's (2002) description of epistemic authority as "students . . . given authority in addressing [intellectual] problems" (p. 400). A student's epistemic authority can be recognized by how his or her contributions to an activity are continuously recognized. As the student's epistemic authority is recognized, the student's idea begins to be recognized for its value and addressed in discussion. In small-group argumentation activities, students are situated with more authority and responsibility to shape the structure of their activity. Thus, I expand Engle and Conant's description by including students' contributions toward building and modifying the existing structure of the activity in which they are participating.

1.2. Research Questions

The purpose of this study is to explore how student agency facilitates group members' framing of their positions as collaborative contributors to knowledge development in argumentation activities in science classrooms. Three sub-studies were conducted for this purpose in this study. First, in Chapter 3, I conducted a theoretical investigation of how student agency has been explored and discussed in the literature, wherein I explored how student agency has been investigated in science education and delineated the previous studies' approaches to the analysis of agency in students' practices in learning communities. Based on these findings, I developed an approach to discuss student agency as the capacity to facilitate a shift in group members' framing in small-group argumentation activities. The next two chapters describe two case studies that explored argumentation activities in science classrooms. These argumentation activities were designed to facilitate students' framing of argumentation activity as a process of collaborative knowledge construction, highlighting the dialogical features of scientific argumentation. The first case study explored the case of a small group of students who shifted their shared framing through discussion and acknowledged one another as collaborative contributors in the development of communal argument (Chapter 4). This study demonstrates how student agency plays an important role in facilitating the negotiation and shift in students' shared framing. In the second case study, I explored the case of a small group with a marginalized student (Chapter 5). In this study, I identified various discursive moves that reflected student agency as facilitating the negotiation of the framing of argumentation activity and their positions in the activity. The specific research questions were as follows.

Study I. Theoretical investigation on student agency to develop the analytical framework of student agency facilitating the shift in shared framing (Chapter 3)

(1) What aspects of agency have been discussed in relation to student practices in science education?

(2) How have student practices in learning communities been investigated in science education?

(3) How can the interplay of student agency and framing shifts in small-group argumentation activity in a science classroom be captured?

Study II. Framing oneself and one another as collaborative contributors in small-group argumentation in a science classroom (Chapter 4)

(1) How do students shift their personal framings of their positions in an argumentation activity?

(2) How is the shift in shared framing facilitated in a group?

Study III. A marginalized student's attempt to position himself as a collaborative contributor in small-group argumentation in a science classroom (Chapter 5)

(1) What were the discursive moves that reflected student agency in attempting to become a collaborative contributor in small-group argumentation activities?

(2) How did the students negotiate their framing of small-group argumentation activities in the interactions following the discursive moves?

(3) How did the argumentation activities in the science classroom context affect the students' negotiation of framing?

1.3. Significance of the Study

This study attempted to delineate student agency as students' capacity to facilitate students' shifts to position themselves as collaborative contributors in argumentation activities in science classrooms. The literature has explored the contexts that facilitate shifts in students' framing, emphasizing that student practices can shift as their framing of the classroom activity shifts (e.g., Berland & Hammer, 2012; Hutchison & Hammer, 2010; Rosenberg *et al.*, 2006). However, even in a classroom environment designed with these contexts to facilitate students' framing shift, many students persist in relying on authoritative sources for the delivery of information. In this study, based on the findings of the previous studies, I identified student agency in students' framing shifts. Based on the findings, I argue that the contexts that previous studies identified as facilitating students' active participation in discussion are the contexts that facilitate students' negotiation of framing and that students' agency plays a key role in shifting their framing of an activity to a collaborative meaning-making discussion.

Furthermore, this study demonstrates that it is important to facilitate students' positioning of themselves as collaborative contributors and not merely as a group of individual knowledge developers in dialogical argumentation activities in science classrooms. In the previous studies, the focus has mostly been on how to modify the power difference between teachers and students. To form a collaborative learning community, it is necessary for students to acknowledge not only oneself but also one another as contributors to the development of communal knowledge. This study explored how students attempted to be accepted by other group members as contributors in the development of knowledge, and how students

acknowledged one another as such. This study contributes to our understanding of the construction of collaborative learning communities in argumentation activities in science classrooms.

1.4. Overview of the Dissertation

This dissertation is composed of six chapters. In Chapter 1, the research questions and significance of the study are briefly described. Chapter 2 focuses on the literature that provides the theoretical framework for this study. In Chapter 3, I describe the theoretical investigation of student agency in previous studies, and I develop an approach to discuss student agency as facilitating the shift in shared framing in group discussion. Chapters 4 and 5 describe the two case studies that were conducted in this dissertation. Chapter 4 describes a case that shows the agency of a student who facilitated her group members to acknowledge each other as collaborative contributors in the development of a communal argument. Chapter 5 discusses a case of a marginalized student's diverse attempts to be accepted as a contributor in his group and delineates the discursive moves that reflected his agency and that facilitated the negotiation of framing of the argumentation activities. In Chapter 6, based on these three studies, I draw conclusions about student agency in the shift in students' framing in argumentation activities in the science classroom and discuss the study's implications.

Chapter 2. Literature Review

2.1. Overview

In this chapter, I review the literature that has provided the theoretical framework for this study. The study is based on three main groups of research studies. The first group is studies on argumentation activities in science classrooms. These studies have emphasized argumentation activity as a core activity that reflects the social aspects of the scientific community's epistemic practices. The studies have argued that students can not only develop an understanding of the nature of science by participating in argumentation activities but also further develop an understanding of scientific concepts and critical thinking ability. Importantly, the studies have suggested that argumentation activity is an activity in which students can position themselves as agents of knowledge construction. Second, I also ground this study on the studies of student agency. These studies have their basis in Sewell's (1992) discussion of the dialectical relationship of agency and structure. The authors of these studies designed the activities in which students participated as agents in science education based on Sewell's notion. The third research group is studies that have explored students' understanding of science learning from the framing perspective. These studies have emphasized that it is important for students to frame argumentation activities as activities in which they are expected to, and granted the opportunity to, actively participate in the process of knowledge development. They have also argued that students' framing of such activity is context-specific, rather than fixed and invariant, or gradually developing. This study uses the concepts of framing and agency to explore students' shifts in their shared framing of argumentation activity and agency that facilitate this process.

2.2. Dialogical Argumentation in the Science Classroom

2.2.1 Argumentation activity in the science classroom

Scientific argumentation is described as a process of justifying and critically evaluating a knowledge claim about natural phenomena (Driver *et al.*, 2002; Duschl & Osborne, 2002). To be acknowledged for the knowledge claim they devise as the knowledge of the scientific community, scientists justify the validity of such knowledge on the basis of the evidence they have collected to persuade other community members of the validity of the knowledge claim. Then, the community members collectively critically evaluate, revise and develop the knowledge. Scientific knowledge is developed through this social process, and argumentation activity is emphasized as a core activity that reflects these social aspects of scientific community's epistemic practices (Kolstø & Ratcliffe, 2007).

The knowledge products produced in this process are called arguments. The structure of such arguments is described in various ways (McNeill & Krajcik, 2008; Sampson & Clark, 2008; Toulmin, 1958). For example, Stephen Toulmin (1958) delineated the pattern of argument by data, warrant, backing, claim, and rebuttal. However, it is difficult to clearly delineate each constituent of an argument from students' argumentation in classroom, which mostly reflects the features of informal reasoning. Thus, McNeill and Krajcik (2007) suggested a simplified framework to analyze students' arguments with the following three components (p. 55): claim (a conclusion or hypothesis about the given problem), evidence (the relevant data that support the claim), and reasoning (a justification that connects the claim and the data).

Argumentation activities have been enacted in the science classroom to provide opportunities for students to be at the center of the process of knowledge construction. Like scientists in the scientific community, students are expected to participate in the activity as agents who develop knowledge through interaction with others. They are expected to apply their knowledge and construct knowledge claims about various natural phenomena in their own voices.

However, since didactic instruction has long been established in the science classroom, it is difficult for students to suddenly participate in the epistemic practices of the scientific community simply by introducing argumentation activities into science classrooms (Berland & Hammer, 2012; McNeill *et al.*, 2017). These findings indicate that there can be diverse forms of learning communities in science classrooms, which reflect some, but not all, features of scientific communities; thus, scientific communities and science classrooms are by no means identical. Therefore, this study intends to distinguish 'argumentation activity in the science classroom' from argumentation in the scientific community.

Various aspects of the significance and the necessity of enacting argumentation activity have been explored and discussed. First, the studies have shown that argumentation activities can provide students with opportunities to produce new knowledge based on their existing cognitive framework. For example, Maria-Pilar Jiménez-Aleixandre (2002) explored an argumentation activity about wetland environmental management and analyzed the components of knowledge developed by the student participants. Based on this analysis, she noted that the students used their knowledge in the development of reasoning to justify their claims.

Additionally, argumentation activity can provide students with an opportunity to understand the culture of the scientific community. Traditional science learning can be understood as the process of scientists immediately gaining knowledge by observing and experimenting on natural phenomena, as if "nature speaks directly to us" (Driver *et al.*, 2000, p. 4). Driver *et al.* (2000) noted that in the science classroom, the main focus was on delivering scientists' explanations; even if experiments are conducted in the classroom, they are mostly confirmatory. He pointed out that this approach could lead students to perceive that science is developed only through successful discoveries from nature.

Scientific argumentation is an activity that accentuates the social aspect of the scientific community's knowledge development. By supporting students' participation in argumentation activities in science classrooms, we can facilitate their understanding that scientific knowledge is produced through a process of justification and critical evaluation among scientists (Bell & Linn, 2000; Berland & Hammer, 2012; Ryu & Sandoval, 2012). This approach is buttressed by Bell and Linn's work (2000). They conducted a survey of how students perceive scientific knowledge—that is, their epistemological beliefs. The study found that students who perceive that scientific knowledge can change dynamically and that scientists evaluate their knowledge based on evidence construct more complex arguments. These findings imply that students' epistemic practices in argumentation and their epistemological understanding are closely related, and we can infer that the participation in argumentation activities and experience in the development of knowledge claims can enhance students' understanding of the scientific community.

The literature has also shown that critical thinking abilities develop as students participate in argumentation activities in the science classroom and as they

evaluate the reasoning of others' arguments (Jiménez-Aleixandre & Puig, 2012; Kuhn & Crowell, 2011; Sampson & Clark, 2009; Osborne *et al.*, 2004; Zohar & Nemet, 2002). Critical thinking ability is described as the ability to construct a reasonable argument by examining the evidence and criteria for evaluation and reflecting on the validity of the argument (Jiménez-Aleixandre & Puig, 2012; Kuhn, 2005). Jiménez-Aleixandre and Puig (2012) delineated the components of critical thinking as follows: (a) "to be able to evaluate knowledge on the basis of available evidence, which involves the use of epistemic criteria or standards to judge the knowledge claims subject to evaluation" (p. 1005) and (b) "dispositions . . . to seek reasons for own or other's claims and to challenge the authority as sole support for claims, as opposed to uncritical acceptance of authority" (p. 1005). Critical thinking can indicate an individual's ability to reason and can be a collaborative and social process undertaken by multiple people (Kuhn, 2005).

Kuhn and Crowell (2011) described the key features of argumentation activities that facilitate students' development of critical thinking ability. Specifically, they conducted a three-year longitudinal comparison study to investigate the effects of participation in dialogic argumentation activities on the improvement of reasoning skills. The dialogical features of argumentation were highlighted in the activities by the design of the activities that facilitated discussion between the students with opposing perspectives and asking the students to develop the argument in consideration of alternative arguments and rebuttals. Analyzing the arguments that the students constructed in each year, the researchers described that the students who participated in the dialogic argumentation activity were able to develop arguments with more reasoning and evidence, as they considered other perspectives and developed awareness of the components of arguments.

Third, students can deepen their understanding of scientific concepts in argumentation activities. The studies have shown that students can develop a new knowledge claim by using their prior experiences and knowledge when participating in argumentation activities (Eskin & Ogan-Bekiroglu, 2013; Jiménez-Aleixandre, 2002; Ogan-Bekiroglu & Eskin, 2012; Park & Cha, 2016; Von Aufschnaiter *et al.*, 2008). For example, Von Aufschnaiter *et al.* (2008) showed that students participating in argumentation activities construct complex arguments by elaborating, abstracting, and utilizing their prior knowledge. Eskin and Ogan-Bekiroglu (2013) and Ogan-Bkiroglu and Eskin (2012) interviewed tenth graders in argumentation activities. In the interviews, they found development in the students' understanding of the scientific concepts with which they engaged in the activities. In the Korean context, Park and Cha (2016) conducted an argumentation program for gifted elementary science students and tested the students before and after the program. In that study, the researchers found a significant change in the students' understanding of the concepts, supporting the positive effects of argumentation activities on the improvement of the students' understanding of scientific concepts.

2.2.2 Dialogical features of scientific argumentation

Various features of argumentation have been discussed in the literature (Van Eemeren *et al.*, 1996), and this study focuses on the dialogical features of scientific argumentation. The dialogical features of argumentation activities highlight argumentation as an activity in which multiple participants critically evaluate alternative knowledge claims (Ford, 2012; Kuhn, 1991; Nielson, 2013). This study emphasizes that argumentation activity is a social process as well as a

cognitive process (Kuhn, 1991). Dialogical argumentation is usually depicted in terms of the participants sharing different perspectives to develop a persuasive discussion rather than quarrelling (Chinn & Clark, 2013). In this dialogical argumentation, the development of reasoning to justify claims based on evidence is described not solely as an individual's thought process but rather as a mode of social work of critical evaluation and revision with others (Kolstø & Ratcliffe, 2007).

Dialogical argumentation can be categorized in various ways (Felton, Garcia-Mila, Villarroel, & Gilabert, 2015; Kolstø & Ratcliffe, 2007; Walton, 1989). For example, Kolstø and Ratcliffe (2007) categorized the types of dialogical argumentation into disputational, cumulative, and exploratory talks in reference to Mercer's discourse categorization (2000). Disputational talk is a type of discourse in which "the differences of opinion are stressed rather than solved" (p. 119). In this type of talk, the conflict between speakers who support different claims is emphasized. Cumulative talk is a type of discourse in which the speakers' ideas correspond with one another; thus, the same opinion is repeated, or reasoning that justifies the opinion is elaborated. Exploratory talk indicates a type of discourse in which various alternative arguments are suggested, critically evaluated and made more sophisticated. There are several other ways to delineate different types of argumentation activities, indicating that by participating in dialogical argumentation activities, students can enhance their ability to collaborate with other people in different contexts for various purposes.

The dialogical features of argumentation activity are key to explaining the process by which the scientific community revises and develops communal knowledge. Furthermore, the fact that a particular knowledge claim has undergone

a critical review is a basis for believing the validity of the claim; thus, the dialogical feature is considered an essential aspect of scientific argumentation (Ford, 2012). Based on an understanding of scientific argumentation with an emphasis on its dialogical features, this study explores students' practices and understanding in argumentation activities in science classrooms.

2.2.3 Small-group argumentation activity

Small-group discussion is used as an instructional method that provides each student with space to actively participate in discussion (Bennett *et al.*, 2010). Bennett *et al.* (2010) reviewed the introduction of small-group discussions in science education. This paper defines small-group discussion as follows (p. 74):

- involves groups of two to six students;
- has a specific stimulus;
- involves a substantive discussion task of at least two minutes;
- is either synchronous (i.e., face-to-face) or asynchronous (i.e., mainly IT-mediated); and
- has a specific purpose.

This study explored classrooms in which small-group argumentation activities were enacted to provide each student with space for participation; these activities met the above criteria. Each subgroup consisted of three to six students who were given dialogical argumentation activities on scientific concepts as a task for small-group discussion. In each activity, the students were asked to discuss phenomena that can raise multiple alternative claims or an alternative argument for

critical evaluation. Then, they were asked to develop a consensual knowledge claim for the given phenomena or consensual evaluation of the given argument.

According to Bennett *et al.* (2010), science education has begun to emphasize small-group discussions to provide students with the opportunity to explore their own ideas and to promote social interaction. Student discussion was emphasized in Millar, Osborne and Nott (1998) that it is important for students to participate in discussions to promote their development of scientific literacy. In addition, many studies highlighting argumentation activities have designed and explored students' argumentation activities in the form of small-group discussion (e.g., Cho, Ha, & Kim, 2019; Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Lee, Park, & Kim, 2016).

Small-group discussion has the advantage of increasing each student's opportunity to participate in the interaction (Kang *et al.*, 2004). In this sense, small-group discussion is a classroom activity that is in line with the social constructivism perspective, which perceives students as agents of knowledge construction. Springer, Stanne and Donovan (1999) specifically discussed the motivational, affective, and cognitive advantages of small-group discussions. Regarding the motivational aspect, small-group work helps students to recognize the value of the products and success of the entire group rather than competing individually. Thus, small-group discussion can create an atmosphere in which students encourage one another's achievements rather than being competitive. Regarding the affective aspect, small-group discussion can provide students who are marginalized in the traditional classroom with the opportunity to use their voice. Regarding the cognitive aspect, each student is given more space to participate in the discussion and share his or her ideas; thus, every student has more chances to

form new knowledge based on prior knowledge.

However, Bennett *et al.* (2010) noted that these advantages and effects of small-group discussion emerge when students understand the purposes and norms of small-group discussion. Jiménez-Aleixandre *et al.* (2000) argued that productive discussions can occur when the development of students' epistemological understanding of argumentation activity is supported. These studies indicate that it is necessary to understand how students' discussions unfold in small groups and to support their collaborative participation in dialogical argumentation. In line with these studies, this study designed and enacted argumentation activities in the form of small-group discussion in science classrooms to support students' active and collaborative discussion.

2.3. Student Agency in Science Learning

2.3.1 Student agency in science education

The specific interpretation of agency varies from study to study; however, this concept has been discussed in the literature in education with a common meaning of the capacity to act according to one's choice (Bandura, 1989; Emirbayer & Mische, 1998; Giddens, 1979; Pickering, 1995; Schlosser, 2015). The concept of agency began with discussions about whether individuals can be volitional beings with their own will, and it developed further during the Enlightenment, with Locke and Kant emphasizing human free will. Based on their theories, agency was discussed and elaborated as the actions of the knowledgeable actor (Emirbayer & Mische, 1998; Schlosser, 2015). The discussion continued through the debate about whether human beings can act based on their own will or

whether they are merely following a predetermined path according to their already determined fate or the surrounding environment.

In science education, many studies have been based on the dialectical relationship between agency and structure (Sewell, 1992) to explore how the structure of a learning activity influences student agency and how student agency in turn changes the structure of the activity. Additionally, studies have explored students' agentic practices from the activation of their resources and reflection on their practices to pursue activity goals (e.g., Stroupe, 2014; Tan & Barton, 2008; Varelas, Tucker-Raymond, & Richards, 2015). Other perspectives have been used to explore student agency in science education. Emirbayer and Mische's operationalized approach to agency (1998) provided a basis for such research in science education. Bruno Latour (1991/1993, 2005) and Andrew Pickering (1995) criticized the discussion of agency only in human beings and provided a perspective for discussing material agency. Holland and associates (1998) approached agency from the cultural anthropological perspective and discussed the activation of cultural resources in the community work with participants' position and identity, providing a perspective to explore agency through participants' social relationships. Yrjö Engeström (2005, 2008) discussed agency as participants' coordination of an activity structure, which provides a perspective from which to analyze how participants continue and develop such activity through negotiation. He delineated six specific elements of an activity, such as objects, tools, and division of labor, to explore the aspects of participants' negotiation.

In science education, student agency has been discussed from different perspectives according to the research problem being explored and the research context being analyzed. Chapter 3 specifically describes how student agency has

been addressed and analyzed in the science education literature. In this study, student agency is explained as students' capacity to facilitate the shift in the group members' shared framing so that they can position themselves as collaborative contributors in small-group argumentation. I will explain how the perspective on student agency in this study was developed based on the analysis of the previous literature on student agency. To explore the interplay of agency and framing, this study is grounded on studies of the dialectical relationship between agency and structure (Sewell, 1992), which I will explain in the following section.

2.3.2 Dialectical relationship of agency and structure

This study is grounded on Giddens and Sewell's notion of agency and structure. Anthony Giddens (1976, 1979, 1981, 1984) argued that structure and agency are closely related to each other, providing a perspective from which to discuss agency in terms of the structure of society. In contrast to theories of extremes, which argue that human action is caused by the social structure or by an individual's own will, Giddens (1981, p. 19) argued that it is necessary to transcend this opposition between "action" theories and "institutional" theories. He noted that the social structure created through agents' social practices is used by agents for social practices and that we can understand society by exploring this process. Giddens referred to this concept as the notion of "the duality of structure" (Giddens, 1979, p. 5) and referred to the theory as "structuration theory" because his theory was more than a simple combination of previously dualistic thoughts (Giddens, 1979).

Giddens (1976) defined "action" as "the stream of actual or contemplated causal interventions of corporeal beings in the ongoing process of events-in-the-

world" (p. 75). In other words, action is described as a human process that can cause a change in the existing social structure. He emphasized that knowledgeable agents can construct social worlds through actions. However, he noted that, while transforming the social structure, agents can also be influenced by the structure that enables and constrains their actions and interactions (Giddens, 1981).

Giddens (1981, 1984) explained structure as a process in which the social practices of agents continue to spread in time and space, with rules and resources as the components of this structure. He defined rules as "generalizable procedures applied in the enactment/reproduction of social practices" (1984, p. 21). Based on the notion that human actions are closely related to power, he defined resources as "the media whereby transformative capacity is employed as power in the routine course of social interaction" (1979, p. 92). He divided resources into authoritative resources (power over people) and allocative resources (power over materials), according to the object of the power being exercised. This concept was later criticized by Sewell and used as a basis for Sewell's definition of structure.

Sewell (1992) suggested several criticisms on Giddens' notion of structure. First, he noted that Giddens' concept of structure is too rigid to explore changes in the social structure. He added that this conceptualization lacked space for a discussion of human agency, and he separated the concepts of structure and agency. Second, he criticized Giddens' descriptions of structure as stable, which "awkwardly" leads to changes in structure, which can be shown to occur outside the structure. Third, the relationship between structure and culture has been discussed differently in sociology and anthropology. Sewell noted that while sociology has discussed structure and culture as contrasting concepts, anthropology has discussed structure as a part of culture. Thus, he argues that it is necessary to

redefine the concept of structure.

Based on Giddens's (1976) notion of the duality of structure, Sewell elaborated the point that structure and agency serve as premises for each other. He advanced Giddens's depiction of the perception of structure as a process rather than a steady state. Then, Sewell argued that "structures shape people's practices, but it is also people's practices that constitute (and reproduce) structure" (p. 4). He explained that agents can demonstrate "structurally formed capacities to work in creative or innovative ways" (p. 4) and can also change the structure, which demonstrates the duality of structure.

Sewell also pointed out that Giddens's notion of the duality of structure is useful. However, he noted that in *The Constitution of Society* (Giddens, 1984), Giddens vaguely described structure as "rules and resources, recursively implicated in the reproduction of social systems." Sewell developed his theory by elaborating on Giddens's definitions of rules and resources. He criticized the use of the term "rules" to refer to explicit phrases, and Giddens's vague definition of its meaning. Then, he changed the term to "schemas," a virtual concept whose generalizability and transposability cannot be explained by specific concrete practices in particular contexts (p. 8).

In terms of resources, while Sewell agreed that resources presuppose an uneven distribution of power, he nevertheless criticized the vagueness of Giddens's definition because from such definition, we find that resources are divided into authoritative resources and allocative resources. Sewell simplified Giddens's notion by dividing resources into human resources (physical strength, dexterity, knowledge, and emotional commitments that can be used to enhance or maintain power (p. 9)) and nonhuman resources (objects, animate or inanimate, naturally

occurring or manufactured, which can be used to enhance or maintain power (p. 9)). Then, he defined agents as "empowered by the access to resources of one kind or another" (p. 10). This theory was adopted by studies in science education that described how the structure of learning activity affords certain students greater access to resources and delineating epistemic authority to the others (Varelas, Tucker-Raymond, *et al.*, 2015).

However, Sewell faced difficulties in delineating structure as "virtual" by including resources in the structure because in many cases, resources exist before our eyes, and we can sense their existence. Therefore, to maintain the virtual nature of structure, Sewell considered resources to be the "effect of structures." He therefore defined structure to be "schemas with a purely virtual existence, and resources not as coequal elements in structure but as media and outcomes of the operation of structure" (p. 12). This definition of structure, in turn, might place agents utilizing resources in passive positions, with their actions being determined by schemas. However, since schemas are also sustained or reproduced over time by the agent's enactment and accumulation of resources, the notion of the duality of structure is maintained.

Furthermore, Sewell made five changes to the concept of structure to make it possible to explore the process of structural change from within the structure. The first change is that the levels and modalities of structure vary, which indicates that there are diverse schemas and diverse resources for agents to use. The second change is that schemas can be applied in a variety of contexts, which allows for the variety of situations that can be brought about by agents' actions to be understood. The third change is that the accumulation and utilization of resources cannot directly determine the results because we do not know which

schema will be adopted or in which context. Furthermore, this limited knowledge implies that we cannot predict whether the accumulation and utilization of resources will validate or invalidate a particular schema, which leads to the possibility of structural changes. The fourth change is the polysemy of resources, which implies that various agents can be empowered in a particular situation. The last change concerns the intersection of structures, which indicates that a variety of schemas can be intertwined in one situation; thus, different resources can be activated and accumulated by various agents. As such, Sewell has changed the rigid definition of structure in five respects, allowing agency to be discussed in relation to structure.

Based on the above description of structure, Sewell described the agent as follows:

> Agent means to be capable of exerting some degree of control over the social relations in which one is enmeshed, which in turn implies the ability to transform those social relations to some degree . . . agents are empowered to act with and against others by structures: they have knowledge of the schemas that inform social life and have access to some measure of human and non human resources. (Sewell, 1992, p. 20)

Considering this definition, I understand agents as participants who have access to resources and can appropriate and use resources as conceived by Sewell. Agency can be exercised in a variety of ways according to the resources that agents can activate and the schemas that are enacted. Agency and structure are in a dialectical relationship in that agents are empowered by structures and can change and restructure the existing structure. Many studies on students' transformative

agency in science education are grounded on Sewell's perspective.

In Chapter 3, studies on students' transformative agency are investigated in addition to other studies on student agency in science education. Then, in consideration of other perspectives on student agency, in the subsequent discussion, I develop an approach to investigate students' discursive practices that reflect their agency and the shift in group members' shared framing. In short, as explained in the section about the theoretical framework of this study, I posit that the way students activate their cognitive resources to develop an argument is afforded and constrained by their framing—specifically, how they expect their knowledge to be constructed and what they perceive to be their role in argumentation activity. Thus, I view student framing as a main aspect of the schema of students' small-group argumentation activities. I examine student agency in students' discursive practices that facilitate the negotiation of framing in their groups in an attempt to be accepted as collaborative contributors by other group members. More details are described in chapter 3.

2.4. Framing Perspective to Explore Students' Understanding of the Science Classroom

2.4.1 Framing perspective

Framing is one of the perspectives used to explain how participants perceive the activity in which they are situated (Bateson, 1972; Goffman, 1974; Tannen, 1993), which is a tacit answer to the question "What is it that's going on here?" (Goffman, 1974, p. 8). It is difficult to grasp all the elements of an activity in which we are situated, because of our cognitive limitations; thus, we frame the activity based on previous experience relevant to certain elements of the situation

that we have noticed (Tannen, 1993). People can even frame the same activity in different ways, depending on which the aspects of the activity to which they are paying attention, and people's framing can shift if they pay attention to different parts of the activity. Framing is reflected in an individual's practices in the activity, and others can interpret his or her framing from practices and implicitly transfer his or her framing through interaction (Bateson, 1972; Tannen, 1993).

The concept of framing was introduced by Gregory Bateson's work (1972) in anthropology. Bateson found that, although there were no explicitly spoken messages in interactions, there were messages that were implicitly transferred and shared among the participants in an interaction. He argued that these messages work as a framework for interpreting the meaning of spoken words in interactions and, to which he referred as framing. At the beginning of the article, he presented interactions between zoo monkeys as a typical example of framing. Although two monkeys were pushing each other, even the people observing them could clearly observe that they were "playing" and not "combating." Although they were not explicitly told that the actions were "play," the observers could understand and interpret "play" from a particular series of actions.

Following Bateson's work, Goffman (1974) referred to framing as a "framework of interpretation" and said that this framing was socioculturally formed, through interaction with other people in society. People participate in a particular situation and subjectively interpret the situation through various experiences and memories that they already possess. Bateson noted that not just a participant's experience but also his or her motivation and intention are involved in this subjective interpretation of a particular situation. Furthermore, he said that people can change the initial framing and that framing is not fixed; it can be shifted

in the course of interactions.

Based on Bateson's and Goffman's work, Tannen (1993) explained that framing is about a participant's expectations of his or her situation. He went beyond Goffman's discussion by stating that people's socioculturally formed framing can be identified through their interactions. Tannen showed that we can capture a specific framing based on a participant's discursive practices (e.g., utterance, intonation, tone of voice, accent). He also argued that based on Goffman's notion that framing can be shifted through linguistic cues, framing can be dynamically shifted by contextual cues. Tannen presented several discursive examples and showed that participants can interpret one another's framing on the basis of their discursive practices in an interaction and negotiate and shift their framings in various ways.

Framing theory has been widely used in various fields such as media, politics, and economics. For example, Dietram Scheufele (1999) explained how mass media present an event in a certain way through ideologies and attitudes, influencing how people interpret the event. Chong and Druckman's work (2007) in the political communication field used framing theory to explain how framing affects public opinion. In behavioral economics, there has been discussion on how people choose alternative choices when different attributes of a situation are highlighted (e.g., Kahneman & Tversky, 1979).

In science education, the framing perspective has been used as an approach to explore student understanding from context-dependent shifts in their practices (e.g., Hammer *et al.*, 2005; Hutchison & Hammer, 2010; Russ *et al.*, 2012). This perspective is in line with emphases on the exploration of students' epistemological understanding and how students understand the construction of

knowledge in a science classroom, from their practices in the classroom (Sandoval, 2005). The framing perspective enables researchers to understand that student practices can change dynamically, even within the same activity, if their framing of the science classroom shifts in a context-sensitive manner (Hammer & Elby, 2002; Hutchison & Hammer, 2010). Additionally, Russ *et al.* (2012) investigated the context of clinical interview between an interviewer and students and described how the students' epistemological framing can dynamically and sensitively shift as the students paid attention to a key participant in the interaction, the interviewer. The current study also uses a framing perspective to explore how students shift their understanding of an argumentation activity and their positioning within discussion.

Framing can involve various interrelated aspects. Since this study examined students' epistemic practices and their social relationships in argumentation activity, I focused on epistemological and positional framings.

2.4.2 Epistemological framing

Epistemological framing can be described as a participant's expectations of how and what knowledge will be constructed in an activity (Greeno, 2009; Hutchison & Hammer, 2010; Redish, 2004). Epistemology is a theory of knowledge and knowing. In the field of education, studies have investigated students' epistemological understanding because what students think and believe about knowledge and knowing affects their learning (Perry, 1970). Epistemological framing is used as a perspective for exploring students' epistemological understanding.

Epistemological framing involves various aspects such as an understanding of the structure of knowledge and an understanding of the source of knowledge (Hammer *et al.*, 2005; Redish, 2004). The variation is due to how the framing perspective is grounded in an approach that posits epistemological understanding as multifaceted (diSessa, 1993; Redish, 2004). According to this approach, epistemological understanding cannot simply be described as functioning on one level. A student's epistemological understanding consists of various aspects, which are closely related to one another. Thus, for example, when a student perceives that the source of knowledge is textbooks (the source of knowledge), then the student might also perceive that the knowledge is transferred from the textbook rather than constructed by oneself (the way of knowing). This approach allows us to explain the dynamic shifts in students' epistemological understanding of classroom activity as well as the diversity of their framing.

The previous studies have inferred various epistemological framings from student discourse in science learning (Berland & Hammer, 2012; Hutchison & Hammer, 2010; Louca *et al.*, 2004; Rosenberg *et al.*, 2006). Hutchison and Hammer (2010) divided epistemological framings into categories of productive and unproductive based on whether the student focused on accumulating knowledge transferred from experts or on developing a reasonable explanation of natural phenomena. Rosenberg and associates (2006) delineated student framings based on whether the students focused on using "scientific terms" or making sense of natural phenomena. Louca *et al.* (2004) distinguished students' epistemological framing according to the type of knowledge they developed, that is, whether they focused on constructing a teleological explanation or a mechanistic explanation.

Epistemological framing in argumentation activity can be inferred as students' expectations of how knowledge is constructed in the given argumentation activity in the science classrooms (Berland & Hammer, 2012). For example, Berland and Hammer (2010) described students' context-dependent shifts in their framing of the argumentation activity as "idea-sharing," "argumentative discussion," or "discordant discussion." "Idea-sharing," which is the framing of an argumentation activity as the presenting of various ideas, is inferred from discourse in which students share their ideas and acknowledge their contributions. "Argumentative discussion" framing is a framing inferred from discourse in which students exchange critical opinions about the presented ideas and create persuasive, sophisticated arguments. The researchers inferred "discordant discussion" framing from discourse in which these two framings are combined and continuing.

2.4.3 Positional framing

In the literature that has examined students' epistemological framing of discussion in science classrooms, the issue of participant roles in discussion has been addressed as showing how students redefine their roles, shifting from framing as passive recipients of knowledge or simply scientific terms transferred by other authoritative source (Elby & Hammer, 2010; Hutchison & Hammer, 2010; Rosenberg *et al.*, 2006). The positional aspect of framing specifically refers to this aspect, capturing the relationships between participants in an epistemic activity and how they negotiate their relationships through interactions (van de Sande & Greeno, 2012; Watkins, Hammer, Radoff, Jaber, & Phillips, 2017).

Positional framing refers to how individuals entitle or expect themselves and each other to participate in their interactions (Greeno, 2009; van de Sande & Greeno, 2012). Taking a particular point of view—that is, framing one's position in a certain way—is the basis for participating in a conversation (MacWhinney, 2005). Taking a specific perspective or position determines one's particular practices and this perspective or position is transferred to others through interaction (Holland *et al.*, 1998). Then, others will expect that individual to act in that way. The term 'position' is used because it can be dynamically shifted compared to 'role,' which is considered fixed (Harré & Van Langenhove, 1999). This feature is consistent with the notion of framing, which suggests that students' perceptions are context-specific.

The positions that individuals frame are explained from a relative aspect in the sense that people understand their roles in relation to each other's practices (Harré & Van Langenhove, 1999; Holland *et al.*, 1998; van de Sande & Greeno, 2012). In this way, positions are formed through interaction with others under the influence of the culture of the society (Holland *et al.*, 1998). I interpret this relative aspect as having been derived from the concept of position developed by Harré and Van Langenhove (1999), in which position refers to the dynamic feature of a role that shifts with respect to other participants in a conversation.

This concept is reflected in empirical studies in science education that have explored the context-dependent shifts of students' positions in meaning-making activities (van de Sande & Greeno, 2012; Watkins *et al.*, 2017). For instance, van de Sande and Greeno (2012) classified participant positions largely as source and listener according to the direction of the cognitive information transfer between participants. They described how the alignment of students' personal

framings allowed their reasoning to be developed through dialogical discussion. In another study, Watkins *et al.* (2017) described the position of students in a science classroom who played a role of expressing and dealing with uncertainty as "not-understanding." The researchers highlighted this position as an important one that facilitated the shift in student epistemic practices toward a meaning-making process.

2.4.4 Exploration of the contexts that facilitate shifts in students' framing

The framing perspective was adopted in science education to explore students' epistemological understanding of their practices in the classroom (Hammer *et al.*, 2005; Hutchison & Hammer, 2010). Studies have investigated how students' practices shift depending on context (Hammer & Elby, 2002; Hutchison & Hammer, 2010; Louca *et al.*, 2004; Rosenberg *et al.*, 2006; Russ *et al.*, 2012).

For example, Rosenberg *et al.* (2006) explored a case in which students' epistemological framing shifted on the basis of a teacher's support in a modeling activity about the rock cycle. The students focused on using the terminology of science concepts, borrowing the terms presented in an activity sheet. These practices shifted as the teacher suggested, "Start with what you know" (p. 272). The students began to use their expressions in the discussion, focusing on designing models that would reasonably explain the mechanism of the rock cycle. Thus, the teacher's utterance triggered a shift in the students' framing of the activity.

In Hutchison and Hammer's study (2010), a teacher acknowledged students' contribution to the production of knowledge based on the ideas they tried to share rather than the accuracy of their use of scientific terms. The teacher's

support facilitated the students in framing the discussion as the production of knowledge to make sense of natural phenomena, to which the researchers simply referred as “productive framing.” The researchers discussed the idea that the students were able to actively participate in the dialogical discussion with their productive framing.

Louca *et al.* (2004) described a case in which students focused on developing a teleological explanation but shifted to developing a mechanistic explanation after receiving a teacher’s support. The teacher used anecdotes of everyday life to explain that the “why” and “how” questions differ. This explanation served as a clue that facilitated the students in shifting their epistemological framing. Such studies have focused on delineating the features of contextual cues in learning activities that facilitate a shift to productive framing in science classrooms.

These contextual cues are common in that they deliver the message that not only teachers or textbooks but also students themselves possess knowledge and experience that can be used to develop valid knowledge in the science classroom. These findings are significant because they provide useful information on devising instructional strategies to reduce the differences in epistemic authority between teachers and students.

2.5 Chapter Conclusion

I reviewed the literature in the three areas on which this study is based: (a) dialogical argumentation in science education, (b) students' agency in science learning, and (c) using the framing perspective to explore students' understanding of classroom activities. For this study, which explores students' shifts in their positional framing with respect to their being collaborative contributors in the development of communal knowledge in argumentation activities, the studies reviewed in this chapter have the following implications.

First, the studies show that argumentation activity is emphasized as a core activity that reflects the social aspects of the scientific community's epistemic practices. Additionally, these studies indicate that argumentation activity in science classrooms can provide a learning environment for students to position themselves as agents of knowledge development. Scientific argumentation is described as a process of the justification and critical evaluation of a knowledge claim about natural phenomena to develop communal knowledge. Based on studies of the dialogical features of scientific argumentation, this study considers argumentation activity to be a process in which multiple participants share and critically evaluate alternative arguments to develop a communal argument. I interpret communal arguments as being composed of evidence, reasoning and claims that are proposed, rebutted and revised in students' discussions.

Second, studies on student agency in science learning provide a perspective for exploring students' roles in facilitating shift and negotiating the structure of a learning activity. These studies describe the dialectical relationships of student agency and the structure of learning activities in science classrooms.

Based on these discussions in the literature, this study explores student agency in terms of a student's capacity to facilitate changes in the structure of a small-group argumentation activity to position students as collaborative contributors to communal knowledge development.

Third, studies using the framing perspective indicate that students' understanding of an activity can dynamically shift during interactions with others. This notion allows the investigation of students' dynamically changing practices in argumentation activities in the science classroom. The empirical analysis of shifts in students' framing provides useful information on the construction of a classroom environment that facilitates students' productive engagement in argumentation activities. However, there is a lack of discussion about why some students successfully shift to productive framing and the way in which students negotiate the framing of an activity so that they can be positioned and acknowledged as contributors among themselves. In this study, I explored in depth how students facilitate a shift to productive framing and how they attempt to position themselves as contributors in their group.

Chapter 3. Theoretical Investigation of Student Agency to Develop an Approach to Explore Student Agency as Facilitating a Shift in Shared Framing[1]

3.1 Overview

This chapter aims to develop an approach for the analysis of student agency as facilitating a shift in shared framing in small-group argumentation activity in science classrooms. For this purpose, I explored the aspects of student agency that were previously discussed and the ways in which agent practices in learning communities were investigated in the prior research on science education. The results revealed five aspects of agency related to students' actions in a learning community: epistemic agency, transformative agency, educated action in science, disciplinary agency, and material agency. I delineated how agency was examined in student practices, as described in the literature on each of the aforementioned aspects. I also delineated three approaches by which the previous research has examined the practices of students as agents that construct learning communities. These approaches are (a) describing agency as a whole across the entire learning community, (b) describing the influence of a focused student's agency, and (c) describing the interactions between agents. I discussed the implications of the previous research on the basis of each approach to understanding the various features of student-centered learning communities. This work contributes to the exploration and support of students' practices as agents in the learning communities in science classrooms. Additionally, the findings in this chapter contribute to the

[1] The study in Chapter 3 is based on the following previously published study: Ha, H., & Kim, H. –B. (2019). A theoretical investigation on agency to facilitate the understanding of student-centered learning communities in science classrooms. *Journal of the Korean Association for Science Education, 39*(1), 101–113.

development of an approach to explore students' discursive practices that reflect their agency and negotiation of framing in subsequent discussions with other group members.

3.2 Chapter Introduction

Many studies and curriculums in science education have aimed to help students exercise agency in science learning. In most of the studies that highlight student agency, learning activities with students as agents are compared with the teacher-centered didactic classroom. Discussions of student agency in previous studies are similar in their description of agency as a capacity to act based on one's own choices. This general feature of agency is also highlighted in the perspectives that the studies have adopted to discuss agency (Bandura, 1989; Emirbayer & Mische, 1998; Giddens, 1979; Schlosser, 2015). However, the specific descriptions of practices of students as agents vary from study to study according to their perspectives on agency, the learning activity and the research questions investigated. For example, some studies discuss student agency in terms of students' participation in knowledge-developing discussion (Sharma, 2007; Stroupe, 2014), while other studies emphasize transformations in learning activity (Basu & Barton, 2009; Basu *et al.*, 2009).

The variety of discussions on student agency led me to first question how the science education literature has discussed science learning and student agency. This is an important question to build a basis for developing an approach to explore student agency as facilitating a shift in shared framing. In addition, it is important to consider how previous studies have explained learning communities of students as agents since this study focuses on students' collaborative development of

communal knowledge. Thus, in this study, I explored the following specific questions:

(1) What aspects of agency have been discussed in relation to student practices in science education?

(2) How have student practices in learning communities been investigated in science education?

(3) How can the interplay of student agency and framing shifts in small-group argumentation activity in a science classroom be captured?

3.3 Research Context and Methods

3.3.1 Selection of literature as subject of the analysis

This study aims to explore how the concept of 'agency' has been discussed to explore students' active participation in science education. The selection of the literature for the analysis began with reviews on the concept of agency in the education field (Arnold & Clarke, 2014; Matusov, von Duyke, & Kayumova, 2016; Shanahan, 2009; Varelas, Settlage, *et al.*, 2015). Then, I expanded the search from these reviews, searching for the studies referred to in the reviews and those that referred to the reviews. I also searched for other studies within science education by using Google Scholar to search for the keyword "agency." I selected studies that follow Emirbayer and Mische (1998), which analytically disaggregated and conceptualized agency in sociology. This study provided a picture to understand and discuss agency in the social world, and it was referred to extensively in the subsequent studies including those in the educational fields. Thirty-six studies were selected as the main subject of the analysis. I

additionally referred to the literature in other fields, which provided theoretical backgrounds for the selected studies, so that I could identify the perspective from which the studies explored student agency. Overall, I referred to 45 studies in the educational fields other than science education and 40 studies in the fields of philosophy, cultural anthropology, and linguistics.

3.3.2 Analysis

I explored each literature selection with the following questions: which aspect of agency was mainly discussed based on what theoretical background and how student agency was captured in terms of student practices. Specifically, the focus was on how learning and knowledge construction were framed and how they framed agency based on their framing of learning. In the case of the studies that used empirical analysis, I also explored how these framings were applied in the analysis. Specifically, I investigated the context of the epistemic activities in which the students engaged, the structural aspects of the activities that afforded or constrained agency among the participating students as agents, and the features of the student practices from which the researchers gauged student agency.

Based on this analysis, I delineated the aspects of agency discussed in science education. To identify the different aspects of agency, I referred to Markus Schlosser's (2015) overview and categorization of agency and added other aspects of agency that were not identified in Schlosser's study but were discussed in the science education literature. I also explored how each aspect was discussed in the literature that provided theoretical backgrounds for the studies in science education.

To answer the second research question, I focused on the studies that empirically explored student practices, identifying how each study interpreted student practices, how it viewed students as agents in the learning community, and how they explored agents' interactions with one another. In this analysis, I excluded studies that did not fit the research question. For example, I excluded studies that did not focus on student practices in the context of the science classroom or informal education (Lee & Roth, 2004; Siry & Lang, 2010), studies that focused on exploring the structure of activities that constrain agency (Brickhouse, Lowery, & Schultz, 2000; Carlone, Johnson, & Scott, 2015; Olitsky, 2006; Shanahan & Nieswandt, 2011), and studies that explored agency on the basis of English grammar (Martin, 2016) because it was challenging to extend this focus further into analyzing discourse in Korean, which has significantly different grammar than English. To ensure the validity of the analysis, I repeatedly explored the studies with other researchers, until we reached a consensus in areas where our individual interpretations differed.

3.4 Findings and Discussion

In this section, I first describe the aspects of student agency that were mainly discussed within science education. Then, based on the findings for the first research question, I describe how agent practices in learning communities were investigated in these studies.

3.4.1 Aspects of agency discussed in science education

The following aspects of agency were discussed in the studies depending on the research problem and the contexts of the activity they explored: epistemic agency, transformative agency, educated action in science, disciplinary agency, and material agency. Epistemic agency, transformative agency, and educated action in science are aspects of human agency that were examined as student agency. Disciplinary agency and material agency were discussed in studies that took the perspective that agency is not solely a human property. These studies perceived the discipline in which the participants were working and the materials with which the participants interacted as also exercising agency in the context of human work. The following sections describe how each aspect of agency was discussed and through what types of activity the studies explored agency, in other words, the features of the activity structures that the studies explored.

Epistemic agency

Studies on epistemic agency (Barton & Tan, 2010; Goulart & Roth, 2010; Kane, 2015; Miller, Manz, Russ, Stroupe, & Berland, 2018; Rose & Barton, 2012; Sharma, 2007; Stroupe, 2014; Stroupe, Caballero, & White, 2018; Zimmerman & Weible, 2018) emerged with an emphasis on students playing an active role in the development of scientific knowledge (Ministry of Education, 2015; NRC, 2012). These studies depicted students' practices as agents from their contribution to the development of knowledge. Specifically, epistemic agents are well described in David Stroupe's work (2014) as "individuals or groups who take, or are granted, responsibility for shaping the knowledge and practice of a community" (p. 492). The studies on epistemic agency focused on students' active participation in

discussions that develop knowledge, compared with a teacher being positioned as an epistemic authority. For example, Stroupe explored five science teachers' classrooms that facilitated a shift from the traditional structure, in which science is viewed as accumulated knowledge and students passively receive knowledge transferred from teachers. He explored student agency from students' delineation of knowledge claims and development of reasoning. In Ajay Sharma's (2007) study, the students were described as "passive learners" when they transferred scientific concepts from teachers or textbooks. In contrast to passive learners, student agency was identified as practices that contribute to expanding meaning-making discussion by bringing up relevant ideas.

Justine Kane's study (2015) is another example of studies on epistemic agency. Kane also examined agency in terms of students proposing ideas and contributing to the development of communal knowledge. This study explored classrooms with diverse activities such as writing, drawing, conversation, acting, and observation so that students could experience science in various ways. The researchers and teachers facilitated the students in using their voices and engaging in collaborative discussion to make sense of natural phenomena. For instance, they promoted the students proposing their ideas without having to raise their hands and participating in discussions whenever they wanted. The researcher captured agency as students presenting their own ideas, recognizing differences in their ideas, and negotiating the communal knowledge they constructed through discussion.

Goulart and Roth (2010) explored a curriculum-design activity in which five-year-old children discussed with a teacher the order in which they would learn certain concepts in the science classroom. The researchers described agency in terms of the children proposing various ideas for this activity. They also discussed

that the formerly proposed design provided both affordance and constraint on the ideas in this activity, because each idea affected the way in which the students come up with the next idea. Although this study did not explore the activity in terms of developing explanations to make sense of natural phenomena, the participants engaged in the discussion to develop communal knowledge, specifically, the "science classroom curriculum." In this process, the students' understanding of the concepts was reflected in the discussion, which corresponds to epistemic agency.

Meanwhile, several studies have discussed epistemic agency not only as students' contribution to the development of knowledge but also as the building and transformation of knowledge-developing activity and participation patterns. Miller *et al.* (2018) argued that epistemic agency could be promoted by facilitating students in changing the structures that constrain and support action. This perspective was reflected in Stroupe and associates' study (2018), which described epistemic agency, for example, in terms of a student deciding to expand the data collection that was originally done in the science class into daily life; the teacher announced this decision to other students so that they could join in this shift. In Barton and Tan's study (2010), epistemic agency was discussed in terms of students engaging in the development of knowledge products, reflecting their ideas in the structure of a knowledge-developing activity and deciding how the knowledge could be justified and in what form the knowledge would be produced.

The studies that have argued that students' ideas, rather than teacher or textbook knowledge, should be placed at the center of the class are in line with the literature on students' epistemic agency. For instance, Maskiewicz and Winter (2012) did not explicitly discuss agency in their discussion; however, they explored

two science classrooms that unfolded in different ways as the students interpreted the same phenomena differently. That study can also be described as contributing to the effort to position students as epistemic agents in science classrooms. The studies exploring the contextual cues that facilitate shifts to productive framing in science classrooms (e.g., Hutchison & Hammer, 2010; Rosenberg *et al.*, 2006) can also be explained as focusing on students' epistemic agency. As such, studies on epistemic agency are closely connected with studies that situate students' ideas as potential resources for the development of scientific knowledge (e.g., Ha & Kim, 2017; Hammer *et al.*, 2005; Oh, 2015).

Transformative agency

According to the dialectical relationship between agency and structure, structure is reproduced by agents' participation in an activity. There are various means by which agents' practices function as participation in an activity. One such means is the reuse and following of the resources or schema of an existing structure. In contrast to this aspect, the studies on transformative agency described agency in terms of students leading the transformation of the existing structure of an activity in a science classroom. Transformative agency has been discussed in studies with a theoretical basis in critical theory (Barton & Tan, 2010; Basu, 2008; Basu & Barton, 2009; Basu *et al.*, 2009; Buxton, 2005; Elmesky, 2005; Furman & Barton, 2006; Tan & Barton, 2007, 2008; Varelas, Tucker-Raymond, *et al.*, 2015). Critical theory raises questions with regard to the current world and examines and interprets the power dynamics and hidden structures of the world. The studies on transformative agency grounded in this perspective have aimed to pursue equity for students who are part of marginalized groups in society and in science classrooms (Basu, 2008).

When describing science learning, these studies have focused on students' development of positive identities in science more than the development of cognitive concepts (Brickhouse *et al.*, 2000; Holland *et al.*, 1998; Olitsky, 2006). Identity has generally been described as "who I am in the science classroom," and some studies have also considered "whom I want to be" (Tan & Barton, 2008) and "how I am positioned by other participants." Some studies have also considered how a participant interpreted other participants' positioning of him or her and how he or she reacted to that positioning (Buxton, 2005). These studies have described agency in terms of student practices with the intention to shape and improve themselves or their lives. Structure has been discussed in terms of participants' understanding of how they can activate their resources to contribute to knowledge development. The researchers have focused on how and what affordance and constraints the structure provided for students' positioning in the activity. Then, agency has been discussed in terms of students' development of positive identities, resisting and transforming the activity structure that constrained such positive identities.

Studies on transformative agency have expressed criticisms of how social inequality is reproduced in the science classroom, which does not sufficiently consider students' cultural diversity and socioeconomic differences. In other words, they have argued that students should be viewed not simply as participants in the science classroom but also as members of diverse social communities, such as peer groups and families, and that the potentials of the resources and schemas they bring from those other social structures should be acknowledged. They have highlighted that these communities and community works are sustained by students' agency and their participation in these communities and that science learning is constituted

by their reproduction of practices that reflect their sociocultural backgrounds.

These studies have argued that science classrooms need to provide space for students to develop as agents, rather than reproducing social inequality (Barton & Tan, 2010; Basu, 2008; Elmesky, 2005). Researchers have examined agency as the activation of resources with the aim of resisting or transforming the existing structure. This is clearly described in the following description of the concept of "critical science agency" by Basu and associates (2009):

> . . . One both views the world with a critical mindset and envisions how to advance in the world or change the world into a more socially just and equitable place with and through science, while considering oneself as powerful scientific thinker and doer of science (p. 345)

In another example, Barton and Tan (2010) analyzed a local community club activity in which students voluntarily participated. The students justified their practices with their cultural backgrounds, despite the researcher's other suggestions, and they adjusted their activity. The researchers examined student agency based on these practices. Sreyashi Basu (2008) and Basu *et al.* (2009) explored a physics classroom that provided opportunities for students to engage in the design of a classroom activity. A student, Donya, was one of the cases described to depict transformative agency. The researchers described Donya's positive identity by explaining that she attempted to challenge social stereotypes about the abilities of urban black youth. Then, the researchers depicted Donya's attempts to pursue the goal of the activity. She designed a class about a black hole, planned for classroom debate on questions such as "What do scientists think dark matter is?" and worked as the facilitator and judge, leading the classroom on the day of the debate (p. 347).

Tan and Barton (2007) focused on a girl who transformed from being a marginalized member to a central member of a science classroom. This change appeared in the session in which the students were allowed to bring diverse resources of interest to them, use such resources in the classroom work and share them with the whole class. The study depicted how this girl extended the patterns of discussion, which mainly used scientific terms, that were originally used in the science classroom. In this process, she was able to construct a positive identity in the science classroom and position herself as a central member of the learning community.

As such, transformative agency was captured as both the marginalized student's development of a positive identity and the transformation of the learning activity structure so that the marginalized student's central position could be acknowledged by the other participants. Empirical studies on transformative agency have explored epistemic practices as have studies on epistemic agency. However, those studies are distinguished by their depiction of the student community as a distinct form of learning community rather than focusing on the enculturation of scientific community practices.

Educated action in science

Birmingham and Barton (2014) described agency in terms of students taking action with an intention to contribute to society in an activity about socioscientific issues. They referred to such agency as "educated action in science," describing it as "a capacity to leverage relevant scientific knowledge and practices to inform action(s) taken" (p. 287). The researchers explored a context in which the students investigated a socioscientific issue regarding a city's energy crisis. The

students visited power plants, houses, and colleges in the region and collected data to understand the current situation regarding the rising costs of energy, the declining economy, and climate change. The researchers described student agency in terms of students realizing the seriousness of the problem and producing materials to advertise the issue. The researchers highlighted that the students took actual actions to effect improvement in the local community based on what they had learned. They found that these practices showed student agency, to which they referred as educated action in science. The concept of educated action in science is devised based on studies of transformative agency; however, it is differentiated from transformative agency in that the structure of the activity is viewed in terms of the society beyond the science classroom.

While the studies on transformative agency have focused on knowledge-development activities in the science classroom or community clubs, this study emphasized students' contribution to society. This is in line with the emphasis on students' participation in society on the basis of the knowledge that they built in science learning (Miller *et al.*, 2018; Ministry of Education, 2015; NRC, 2012). The Korean national curriculum emphasizes facilitating students' capacity to "solve personal or public problems through scientific thinking" and to "participate in decision-making with interest in socioscientific issues . . . as members of a social community" (Ministry of Education, 2015). The OECD (2018) also highlights learners' agency in terms of having "the ability and the will to positively influence their own lives and the world around them . . . [and] the capacity to set a goal, reflect and act responsibly to effect change" (p. 2). To better understand this goal of the expansion of science learning into society, it is necessary to further discuss educated action in science.

Disciplinary agency

Disciplinary agency can be described as the agency of a discipline that can be found in people following particular routinized ways of representing and developing knowledge within an established conceptual system (Pickering, 1995; Varelas, Tucker-Raymond, *et al.*, 2015). The discussion of disciplinary agency is ground in Pickering's perspective (1995) that argues that not only humans but also disciplines have agency. According to Pickering, a discipline is sustained by people continuing the routinized work of that discipline. In other words, disciplinary agency is exercised by human work that follows the culture of the discipline. He has argued that to perform a specific pattern of work in a discipline is to follow the culture of the discipline rather than the will of the individual. In this description, the preceding works in the discipline become a model to which people refer when they work in that discipline; thus, the discipline continues and develops.

In science education, for example, disciplinary agency was discussed in the study by Varelas, Tucker-Raymond and associates (2015). They explored students' practices in the context of the integrated science-literacy curriculum, providing various opportunities for students to share their thinking with adults in the science classroom. The students read books on ecological topics and participated in discussions to make sense of the scientific concepts from the books. The researchers discussed disciplinary agency in student's practices that indicated the enculturation of epistemic features of the scientific community while they positioned the students as active participants in the science classroom. Specifically, the researchers focused on a student who began to share his ideas in a hesitant voice and used words such as 'maybe' rather than speaking conclusively with

certainty as he had done before. The researchers interpreted that this change as an indication that the student had realized that his idea was one possibility, not a conclusive answer, and that he was trying to develop knowledge with the other students and not by himself. They discussed how this change reflected the epistemic features of the scientific community, in which various knowledge claims are proposed and shared as possibilities.

Disciplinary agency focuses on practices that can be interpreted as reflecting the culture and practices of the discipline. In studies in science education, discipline means science, and agency is described as a capacity to influence the subject with which one interacts (Gresalfi, Martin, Hand, & Greeno, 2009; Pickering, 1995). Studies conducted in mathematics education (e.g., Boaler & Greeno, 2000; Gresalfi *et al.*, 2009) have discussed disciplinary agency to explore how the structure of the mathematics classroom enables students to participate in an activity as competent experts in mathematics. Studies on disciplinary agency are distinguished from those on other aspects of agency such as those I explained above in that they focus more on practices that reflect those of the expert community. However, it is important to note that these studies do not pursue traditional didactic instructional methods that transfer knowledge to students because it is difficult to support students in engaging in disciplinary work with this type of traditional method (Boaler & Greeno, 2000). The studies on disciplinary agency imply that we should explore how the classroom contexts afford and constrain students' participation in the epistemic practices of the scientific community.

Material agency

The studies on material agency take the perspective that the materials that we explore also have agency. This perspective explains that we, as humans, tend to view material as passive objects without agency that we dominate (Bang & Marin, 2015; Latour, 2013). The material agency perspective holds that material also possesses agency, influencing our work, and that we cannot divide human culture and nature in a dichotomous way (Bang & Marin, 2015; Latour, 2013; Pickering, 1995; Roth, 1999; Roth & Lawless, 2002).

Pickering (1995) did the groundwork in discussing material agency. Material agency is described as material aspects that emergently mangle with human agency to contour the process of knowledge construction (Pickering, 1995). He described how phenomena in the material world do not happen as scientists expect; therefore, the scientists adjust their goals, practices, and understanding of the phenomena. In this sense, he argued that scientists are in a relatively passive position when they deal with natural phenomena. He also has argued that human agency and material agency are intermingled, which means that they affect each other and are both emergently delineated in scientific inquiry rather than one or the other persistently playing the main role.

Bang and Marin (2015) explored material agency in their empirical analysis. They explored data collected in a science learning program that aimed to promote awareness of the declining health of the ecosystem of a lake. The researchers requested that program participants walk around the lake, observe the ecosystem, and discuss how the components of the ecosystem interacted with one another and lived there. The discussion session was organized to facilitate the

participants' understanding that ecosystem components interact with one another and work as agents that construct the ecosystem.

Some studies have discussed material agency in scientific inquiry (Manz, 2015; Pickering, 1995; Roth, 1999; Roth & Lawless, 2002). For example, Wolff-Michael Roth (1999) highlighted that although we usually focus on scientists' discourse when we explore their epistemic practices, this discourse conveys specific meanings because the meanings are grounded in the material world. These studies have explained that phenomena in the material world become a foundation for people's gestures and language and that the knowledge constructed by the use of these interacting tools provides a new perspective for observing phenomena (Roth & Lawless, 2002; Pickering, 1995). Roth and Lawless (2002) empirically analyzed material agency in this sense. They explored students' work in an activity that used a computer program that simulated the Newtonian microworld. The program contained a ball with a "big arrow" and a "little arrow" attached to it (which indicated the force and velocity of the movement of the ball). The students were asked to control the length and direction of the arrows, observe the movement of the ball, and determine the relationship between the arrows and the ball. The researchers focused on the students' discourse in which they indicated various concepts such as velocity, the direction of the ball, and force using the term "big arrow." The researchers also explored the context in which the students conducted an electrostatic induction experiment with a pith ball and rod and constructed an explanation of the phenomena they observed. The students observed the movement of the pith ball, demonstrated various gestures, and came up with new terms to refer to electrons while they constructed an explanation of the phenomena. Then, to determine whether their explanation was valid, they performed trials with various

experimental designs. The researchers discussed how disciplinary agency could be examined from these practices.

Eve Manz (2015) discussed the role of uncertainty in the design of science learning activity. She focused on the uncertainty that scientists encounter due to material agency in their attempts to construct explanations based on observation and experiment (Pickering, 1995). She designed an activity in which students grew plants in the school yard, observed them, and collected data to construct an explanation of the effects of sunlight and moisture on the growth of the plants. Manz described how unexpected changes in the plants' growth, various explanations that were supported by various attributes of the plants (e.g., leaf size, height), and the fragility of the plants resisted the students' scientific inquiry. She explained that although these features constrained the students' work, they also enabled discussion and improved the sophistication of their practices and explanations.

The concept of material agency can be useful in discussing students' practices in relatively open-ended activities. In activities such as project-based learning, R&E (research and education) activities in gifted education, and open inquiry, students frequently encounter unexpected situations (e.g., Lee, Han, Lee, & Noh, 2015; Lee & Kim, 2016; Yun & Kim, 2018). In addition, there has been continuous concern about how teachers should address unexpected results that they can encounter even in closed-ended scientific experiments. The previous studies have focused on discussing the reasoning or level of participation demonstrated by students in dealing with this issue. Material agency and the "mangling" of agency can be useful concepts for discussing how students manage uncertainty and how their epistemic understanding of science is developed. Furthermore, the analysis of

context with uncertainty that facilitates such development can contribute to the design of another prospective science learning activity.

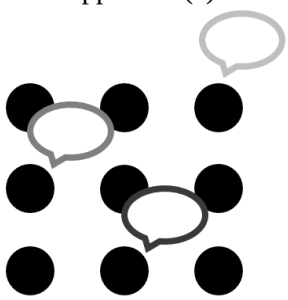
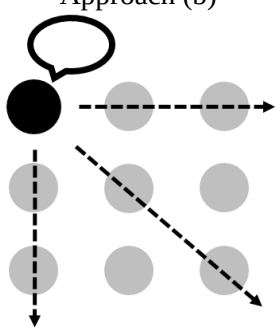
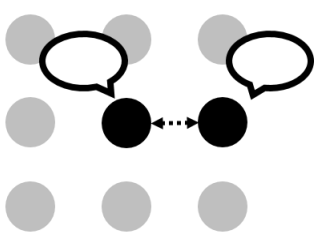
3.4.2 Approaches to examining students' agentic practices in learning communities

Based on the findings discussed in the section above, this section describes how previous studies have examined students' agentic practices in learning communities. Although the studies have all investigated agency with respect to students' practices, they have shown differences in the analysis of agents' practices according to the purposes of each study and the context it explored. I categorized these differences into three types (Table 1): (a) describing agency as a whole across the entire learning community, (b) describing the influence of a focused student's agency, and (c) describing interactions between agents. In each approach, I describe how the studies have framed learning and agency and how these framings have been adopted in their empirical analyses.

Describing agency as a whole across the entire learning community

The studies that have described agency as a whole across the entire learning community (Rose & Barton, 2012; Sharma, 2007; Stroupe, 2014; Stroupe *et al.*, 2018; Zimmerman & Weible, 2018) have mostly discussed epistemic agency. They have highlighted how students can shift from being passive recipients of information to active contributors to the development of knowledge. To delineate this change, such studies have focused on comparing the epistemic authority of students as a group with that of the teacher rather than comparing the power differences among students. Then, the studies have usually investigated the contextual

Table 1. Brief explanations of the three approaches to examining agency in the previous studies

Approaches to examine agency	Brief explanation of each approach
Approach (a) 	Individual students' contributions are described to discuss the agency of the students as a group.
Approach (b) 	Agency is described based on focused students' contributions to the modification of the structure of the learning activity.
Approach (c) 	Agency is described based on students in conflict and negotiation to reach a consensus.

cues that facilitate such change or categorized the discursive moves of students as agents.

For example, Sharma (2007) explored a classroom discussion in which a teacher and students developed a scientific explanation of electrical connections. The researcher classified various discourse patterns according to changes in the

students' roles. In that analysis, the researcher identified the participants as "a teacher" and "students," identifying the students as a group. Then, she identified the students' roles based on whether the teacher's or students' ideas were more prominent in the discussion. One role for students is that of "passive learners" who follow the teacher's instructions. In this case, the discourse begins with the teacher's question, followed by a student's short response and the teacher's evaluation of the student's response. Another role is that of "agents" who bring their daily experiences relevant to electronics to bear on the discussion to develop a coherent explanation. Sharma investigated the contextual cues that facilitate the students' playing the role of agents.

Stroupe (2014) also argued that we should provide opportunities for students to hold the epistemic authority to participate in "authentic disciplinary work" and divided students' roles, as did Sharma (2007). Exploring a classroom activity in which students developed evidence-based scientific explanations, he analyzed whether students perceived the developed explanation as private or public knowledge and the ways in which the teacher's and students' epistemic authority was negotiated. He explored epistemic agency in terms of the students' presentation of knowledge claims and questions to one another, and he described how the students valued one another's ideas and together added their voices to the discussion. Then, he delineated the students' discursive moves in this discussion with the following large categories: making claims, integrating science ideas with other ideas, and asking questions about science ideas (p. 505). This analysis showed that the study aimed to explore the features of the epistemic practices that the students showed as a group rather than exploring interactions within the group. Zimmerman and Weible (2018) also explored students' epistemic agency in terms

of the discursive moves delineated by Stroupe while they explored the context of scientific inquiry with the usage of cell phones to take photos. They also described the students as agents with excerpts that showed the students' active engagement in the development of communal knowledge and discussed how the usage of cell phones facilitated the students' positioning as agents.

Several studies on transformative agency (Barton & Tan, 2010; Barton *et al.*, 2008) have also described students' agency in their group work. Barton and Tan (2010) explored the case of a local community club activity in which students voluntarily participated. In this context, they captured agency as the students' activation of their cultural resources in their work of collecting data and developing communal knowledge. For example, the researchers described the students' use of their experiences and voice to evoke emotions so they could produce an appealing documentary about polar bears. In that work, the researchers discussed students' agency, explaining that the students actively used their culture and experience, rather than merely presenting the knowledge they had received through a transfer from the teacher. The researchers described other students' activities such as conducting interviews as experts on the city they were investigating, and selecting and editing the data to put in the documentary. Similar to the other studies that I described above, this study focused on depicting students' practices that showed that they positioned themselves as epistemic agents rather than focusing on interaction and negotiations among them. These studies argued for a change in the difference in epistemic authority between teacher and students in the traditional didactic classroom; thus, they focused on describing "students'" practices rather than the relationship between the students. Furthermore, the studies explored features of the context that facilitated students in practicing such agency.

Meanwhile, several studies have viewed students as agents in a group although they have not focused on the difference in epistemic authority between teacher and students. For example, Rose and Barton (2012) explored students' discussion of socioscientific issues and described how the arguments that the students developed could differ depending on their perspective on the issue. The researchers examined student agency in terms of the construction of arguments with a distinct perspective that departs from the "commonly accepted" and dominant perspective. Then, they underscored that the students were able to come up with this distinct perspective after the data collection activity, which they describe as the learning context that facilitated student agency. The studies on material agency (Bang *et al.*, 2012; Manz, 2015; Roth, 1999; Roth & Lawless, 2002) are another example of investigating student agency as the first approach. Such studies have focused on the interaction between students' practices and the influence of the natural phenomena they observed in an epistemic activity, identifying the agency of the students as a group and the agency of the natural phenomena.

Describing the influence of a focused student's agency

The second approach is to describe the influence of a focused student's agency in modifying the structure of activities. This approach has usually appeared in the work of Barton and Basu (Basu, 2008; Basu *et al.*, 2009; Furman & Barton, 2006; Tan & Barton, 2007, 2008). These researchers focused on marginalized students in the science classroom and investigated agency with respect to the students' attempts to modify the activity structure so that they could actively participate in activities. Then, they usually described the students' intention for

such transformation of the structure on the basis of the students' narratives that delineated their aim to affect and to modify their life and surroundings (Basu, 2008; Furman & Barton, 2006).

Basu *et al.* (2009) is a representative example of this approach. The researchers explored a physics classroom that provided opportunities for students to engage in the design of a classroom activity. Then, they observed the students' practices and interviewed them to describe their agency through an ethnographic research method. In Donya's case, which I briefly introduced in the section about transformative agency, the researchers delineated her narratives and the teacher's and researchers' observations of her practices to discuss her intentions in how she attempted to design the classroom activity. Specifically, in the narrative, the researchers noted that Donya developed her identity as an "expert scholar and student" (p. 361), who challenged the social stereotype of urban black youth. The researchers also described Donya's activation of her resources in designing and leading the classroom activity. Specifically, she used her debate experience regarding the equation $E=mc^2$ and her local college visit to design the classroom activity. The researchers interpreted Donya's activation of her resources to design and lead the classroom activity as an intention to position herself as an expert scholar and student, which showed her agency.

In another study, Tan and Barton (2007) focused on changes in a girl's participation in science classrooms in an urban middle school over two years. They focused on a girl, Melanie, and explored how she transformed from a marginalized member to a central member of the science class. The researchers explained that this shift began in an activity that allowed the students to use their resources by using search engines in the classroom library to collect data related to their interest

and to produce a report and a poster. Melanie's presentation using her poster differed from other students' presentations, which were supported by other participants. With this event, Melanie's position began to change.

These studies described cases of marginalized students in science classrooms and how they successfully developed their positive identities in science classrooms. The interactions of other students or teachers with the focal student were described to show how they acknowledged the marginalized student's resources and participation. The teachers provided opportunities for marginalized students to present ideas and activate their own cultural resources, and other classroom members are described as acknowledging and supporting such participation.

This discussion implies that for marginalized students to craft positive identities in science classrooms, it is important for other community members, especially teachers, to afford and encourage such shifts. The studies that have focused on specific students have not argued that all cultural resources or perspectives that every student brings in should be embraced (Furman & Barton, 2006). Instead, they have argued that we should provide opportunities for students to share their culture and experiences rather than simply requiring them to conform to the practices of the scientific community (Shanahan, 2009). This perspective affords us the opportunity to explore diverse forms of learning communities that can be built in science classrooms.

Birmingham and Barton's study (2014) on educated action in science also identified agency from the focal students' effects on the transformation of the activity structure. In this study, the community members were not simply students in an activity but agents who contribute to the development of a society with their

knowledge. Although it is difficult to grasp what effects the students as agents specifically had on their society, these types of learning contexts can allow various identities to be developed, and such identities can be expanded to the society outside the science classroom. This enables students to develop expertise in science, an epistemological understanding of science, and the "literacy of democratic citizens" (Ministry of Education, 2015).

Describing interactions between agents in a learning community

The third approach is to describe the interactions between agents in a learning community, underscoring the collision and negotiation between them. Goulart and Roth's work (2010) is an exemplary study that took this approach. They first explained passivity as a concept that is contrary to but parallel to agency. Passivity and agency were described as presupposing each other. Passivity was shown in the acceptance of the practices, resources, schemas, or even intentions underlying the agency of a structure or other agents (Roth, 2007). This approach presented the structure as consisting of resources for agents' knowledge construction. In this case, passivity is not the same as "passive learner" passivity (Sharma, 2007). "Passive learner" passivity means uncritically accepting information and depending on the authority of the information source. In contrast, passivity as a dialectical concept with agency (Goulart & Roth, 2010) indicates learners accepting the necessary information from outside to participate in the construction of new knowledge.

To explain this type of passivity, Goulart and Roth (2010) described a discourse between five-year-old children and a teacher. The class went outside to obtain resources to prove the 'existence of air.' The teacher presented a question,

saying, “Let’s go outside to see if anyone can ‘see’ the air” (p. 536), which was followed by the children’s discourse as they noticed the movement of leaves and commented that the movement was caused by the wind. The researchers remarked that going outside allowed the children to encounter a new structure in which they could observe the leaves and that the teacher’s question suggested a framework for observing the material world so that the students could look for evidence of the existence of the air. This structure allowed the students to capture the resource—the movement of leaves—provided by the structure. Thus, the students both showed passivity in taking in the resources from outside and worked as agents in perceiving the resources. This study is a good example of agency and passivity as accompanying concepts.

From this perspective, some researchers explored a curriculum-design activity in which children discussed with a teacher the order in which they would learn given concepts in the science classroom. When discussing which topic would be covered in the next lesson, the decision on the topic to be covered in the previous lesson worked as part of the structure that the students passively accepted, therefore, afforded and constrained the discussion. The students were placed in a passive position, due to the community members’ previous decisions. Meanwhile, the researchers examined student agency from their presentation of new ideas based on the consideration of previous decisions. Therefore, the researchers interpreted interactions between community members during the development of communal knowledge with agency and passivity in dialectical relationships. In other words, the study focused on how students perceived the activity structure that the community members had previously constructed while also positioning themselves as agents activating the resources afterward.

Kane (2015) focused on how participants experience conflicts when they present their ideas in interactions by exploring conflicts and negotiation among agents during knowledge-constructing discussions. She described conflicts as the moments when participants in a discussion presented different ideas, which was followed by negotiation to reach a consensus. She also described the interactions of classroom community members, delineating how they negotiated the direction of the discussion as they attended to the conceptual resources presented by others.

While Goulart and Roth (2010) and Kane (2015) analyzed conflicts and negotiations between agents with a focus on the knowledge that they constructed, Varelas, Tucker-Raymond, *et al.* (2015) described agency in terms of who led the knowledge development and who was acknowledged as a valid knowledge resource. Then, they explored how agents' practices were accepted or not accepted by other community members. This study also focused on shifts in marginalized students' participation patterns; however, in contrast to the first or second approach, this study focused on the dialectical relationships of agency and structure in analyzing the interactions between students. The researchers depicted how the focal student's attempts to present his idea or new "rules" in a classroom activity were accepted or resisted by other students. They also depicted how the focal student crafted a new space for his participation in the activity and introduced new resources to be used, transforming the activity structure.

The studies using the third approach described how the focal students experienced conflict and negotiation during interactions with other community members. Furthermore, while the studies using other approaches usually focused on how "student(s)" shifted to agents, escaping from reliance on other epistemic authority, the studies using the third approach described the dynamics of the

interactions among these “students” as agents.

An example of the third approach is the study by Stroupe *et al.* (2018). The researchers analyzed how students, a teacher, science education researchers, and scientists shaped a learning activity using Engeström’s cultural historical activity theory (2004). The study captured the participants’ negotiation about how to build the structure of the activity based on the components of activity systems, such as instruments, objects, rules, community, division of labor, and subject. The researchers discussed the activity theory as a useful tool to explicitly delineate these points of conflict and to exercise the community’s collective agency by contriving solutions through negotiation. This idea is in line with the discussion that activity theory can help connect individuals’ interactions and changes in the social structure of the community (Shanahan, 2009). This study described the students’ contributions to the experimental activity in the first approach by depicting how the students engaged in the experimental activity. Meanwhile, the study explained how all the community members, including the students, shared their ideas about how to proceed together in the experiment during moments of conflict. In this sense, the study described the teacher, scientists, science education researcher and students as collaborating agents who shaped the structure of the learning activity. This study, which used the third approach, suggests the possibility of continuing the discussion on students’ and teachers’ agency (e.g., Buxton *et al.*, 2015; Ryder, Lidar, Lundqvist, & Ostman, 2018), which have previously been treated as separate issues.

Examining interactions between students as agents can be a useful way to discuss collaborative efforts in the development of the learning community of which they are members. The second approach also captures the transformation of

the activity structure by the focal student's interactions with other participants. However, the transformation of the structure in the studies that use this approach is mainly depicted by the focal student's activation of resources and the teacher's support for such activation and embrace of these practices. This process differs from the exploration of conflicts and negotiation among agents. The studies that have highlighted students' engagement in science learning as agents have usually compared the practices of agents with the practices of passive learners, or they have investigated the features of the classroom context that facilitated the students' work as agents (e.g., Ha & Kim, 2017; Rosenberg *et al.*, 2006). Exploring students' practices with the third approach can be a useful approach to explore the students' discursive interactions to restructure their activity together, which is one of the main features of being members of the learning community. Furthermore, this notion indicates that the third approach can be adopted to the analysis of students' negotiation of their differing framings in discussion.

3.4.3 Developing an approach for the analysis of student agency as facilitating a shift in group members' shared framing

In this section, I describe an approach to analyze students' negotiation of framing which is facilitated by student agency in their discursive interactions. To investigate students' practices in the context of small-group argumentation activity in particular, I focused on the following three aspects to develop the approach: (a) epistemic authority interpreted from students' recognition of the participants' capability to contribute to the development of knowledge, (b) student agency as students' capacity to facilitate the negotiation of framing, and (c) the schema of an activity explored through the students' framing. The findings of the previous studies provide the grounds for this work.

Epistemic authority interpreted from the students' recognition of the participant's capability to contribute to the development of knowledge

A participant's epistemic authority is identified based on how other students recognize that the participant is capable of contributing to their development of knowledge in the group. This notion is derived from the studies on epistemic agency and transformative agency. These studies have described students' activation of cognitive or cultural resources and discussed how students position themselves in the center of knowledge development. The studies have also shown that such participation and recognition of students as epistemic agents are advanced together in an interrelated manner. The initial supports shift students' recognition of available resources, the students begin to value the potential of their own resources to contribute to a learning activity. As the students' contributions continue, their ideas begin to be recognized and addressed in discussion based on the epistemic authority they hold. By epistemic authority, I refer to Engle and Conant's (2002) description of "students . . . given authority in addressing [intellectual] problems" (p. 400).

With relatively little support provided by the teacher, students are situated with more authority and responsibility to shape the structure of their activity in small-group activities. Therefore, I expand Engle and Conant's description (2002) by including students' contributions to build and modify the existing structure of the activity in which they are participating. Influencing the structure of the activity is what teachers have done in most traditional classrooms and the way in which teachers have held epistemic authority in classrooms (Gore, 1995). Such practices can be interpreted in relation to these teachers' instructional strategies, which lead to dynamic changes in the power relations among the students and their epistemic

authority. It is important to address students' epistemic authority because it plays an important role in how the students accept one another as collaborative contributors in group discussions.

Student agency as students' capacity to facilitate the negotiation of framing

Dialogical argumentation is both a social and a cognitive activity (Chinn & Clark, 2013; Ford, 2012; Kolstø & Ratcliffe, 2007), which indicates that students' social relationships from outside the classroom will be reflected in the activity. Students' initial positions are framed by the influence of their social relationships, and it is necessary for students to negotiate such framings and acknowledge their epistemic authority for them to share a framing of their positions as collaborative contributors. Considering this aspect of argumentation activities, student agency is identified in their discursive practices to attempt to position themselves as co-contributors in collaborative discussion with other students.

To explore student agency in this sense based on student discourse, I focused on studies of epistemic agency and their focus on students' contributions to the development of knowledge and knowledge construction. This study is in line with these studies in that argumentation activity is the context that emphasizes enculturation of scientific community's epistemic practices. I describe student agency as students' capacity to facilitate the negotiation of framing, which contributes to developing arguments and shaping their group's argumentation activities.

I also focused on studies of transformative agency and the directivity of agency, which is shown in the features of agency in these studies—specifically, in

the appropriation of resources while developing positive identities in science learning. I discussed directivity in the description of agency in this study and examined student agency in terms of a student's practices aimed at positioning oneself as a collaborative contributor that facilitate group members' negotiation of and shift in framing in subsequent discussions. Then, in the negotiation of framing, diverse ideas can be shared and reflected in various ways within the negotiated framing. In this sense, student agency can be captured by all the group members participating in the negotiation.

The Schema of an activity explored through the students' framing

As mentioned above, in a small-group argumentation activity, students have more authority and responsibility to shape the structure of their group work than they are used to having in whole-class activities. The context of the activity, i.e., the small-group argumentation activity, is designed to facilitate students' shifts in their framing of their epistemic practices and epistemic roles. Their shifted framings can vary, which will be reflected in their discursive practices. To advance the group's ability to work together, students need to address conflicts and engage in negotiations in their discussions. Therefore, I referred to the third approach to explore students' negotiation of the structure of the activity in the discussion following a transformative agent's discursive practices. Specifically, I explored how each student perceived the activity and how these subjective perceptions were shared and negotiated in discursive interaction. The way students activate their resources and participate in an activity is influenced by their own perceptions of the activity, not someone else's. Thus, as mentioned in the theoretical framework of this study, I adopted the framing perspective to investigate the students'

understanding of how they could, and were expected to, activate their cognitive resources, which is a main aspect of the schema of the activities that students delineate in their discussions.

3.5 Chapter Conclusion

In this chapter, I first explored which aspects of agency have been discussed in science education, and I delineated five aspects of agency discussed in the literature in studies that have examined students' practices as agents in learning communities. Students' practices have been discussed as epistemic agency, transformative agency, or educated action in science. In addition, disciplinary agency and material agency have been discussed as interacting with students' practices. I also described the features of the activities in which the studies explored agency. Second, based on this analysis, I delineated the three approaches by which previous studies have examined the practices of students as agents in learning communities. The approaches were delineated as follows: (a) describing agency as a whole across the entire learning community, (b) describing the influence of a focal student's agency, and (c) describing interactions between agents. Then, based on these findings, I developed an approach to explore student agency during the shift and negotiation of framing in small-group argumentation activity.

These findings have the following implications for the discussion of science education. First and foremost, in this study, I developed an approach to explore student agency that facilitates the shift in the group members' shared framings in the case studies outlined in the following chapters. The analysis on how previous studies have examined student agency provided useful information to

develop this framework.

This study provides other implications for future studies on student agency. This study delineated the five main aspects of agency investigated in the previous studies within science education. The analysis showed that the studies on agency are in line with the literature in arguing that we should provide opportunities for students to engage in the scientific community's epistemic practices and to construct a form of community in which students' cultures are at the center of the classroom community. Specifically, studies on epistemic agency have focused on contrasting students' work as agents participating in epistemic practices that reflect the scientific community's culture with students' reliance on other epistemic authority. The studies on transformative agency place greater emphasis on valuing students' cultural resources and on the development of learning communities that reflect students' culture as well as the scientific community's culture. Furthermore, the studies discussing the mangling of human agency and material agency (e.g., Manz, 2015) provide a perspective for interpreting the difficulties encountered by students and teachers due to the uncertainty of phenomena in the material world. Therefore, I showed how agency can be used to understand students' practices as agents in science learning activities.

In addition, this study delineated three approaches to analyzing students' practices as agents in learning communities with the aim and the context explored in the studies. This analysis provides support for designing future studies to explore student agency in science education. The analysis showed that many studies on epistemic agency argued for students' active participation in meaning-making discussion by focusing on the power difference between teacher and students and describing agency as a whole across the entire learning community. Furthermore,

the analysis showed that more studies on the conflicts and negotiation of students as agents could further develop our understanding of students' craft of structuring learning activities in science classrooms. I expect that these findings and discussion will contribute to the exploration and support of students' agentic practices in learning communities in science classrooms.

Furthermore, this study showed how the specific practices of students as agents in science classrooms have been described. There have been continuous assertions of supporting students' positioning as agents in science classrooms; however, the specific practices of "agents" have varied in such studies. Student agency has been mentioned in many national curricula (e.g., NRC, 2012; Ministry of Education, 2015) as the primary goal of science education. The diversity I have delineated here indicates that we should discuss which aspect of agency is highlighted and how students' specific practices are explored accordingly when we speak of "student agency." Additionally, it is necessary to note that the studies have discussed "student(s)" in different units. Therefore, this chapter showed that we need to engage in further exploration and discussion to achieve the goal of students becoming agents in learning communities in science classrooms.

Last, the findings can contribute to enhancing the sophistication of the concept of agency, which connects to devising instructional strategies to support student agency. For example, based on the findings, the following questions can be raised: Do the five aspects of student agency delineated in this study cover the matters we want in students working as "agents," especially in the Korean education context? How can we view participants in learning communities in science classrooms? Furthermore, many studies have explored students' agency in contexts outside science classrooms (e.g., Bang & Marin, 2015; Barton & Tan,

2010; Rose & Barton, 2012; Manz, 2015). This approach indicates that researchers have perceived constraints on student agency in the structure of the classroom. Therefore, what are the differences between the structures of these contexts and science classrooms that afford or constrain student agency? Answering these questions will facilitate the creation of a science learning environment that promotes student agency.

Student-centered learning has been continuously pursued not only in science education but throughout the education field. Nevertheless, classrooms that limit student participation persist in schools, and we are seeking changes through various efforts to fill this gap. The analysis in this chapter shows that agency is a useful concept for transforming the learning environment and exploring student practices in these efforts. This study contributes to the advancement of these efforts by supporting student-centered learning in the science classroom.

Chapter 4. Framing Oneself and One Another as Collaborative Contributors in Small-Group Argumentation in a Science Classroom

4.1 Overview

This chapter aimed to explore how students not only shift their framing but also reach an aligned framing of their roles as collaborative contributors in argumentation activities and to determine how student agency facilitates this negotiation of framing. Argumentation activities were implemented in a middle school science classroom. I focused on a small group in which the students attempted to engage in interactions with one another instead of remaining passive recipients of authoritative information and in which the students negotiated their positional framings as collaborative contributors during argumentation activities. I coded the positions that the students framed within zones of interaction based on their discursive interactions and explored how their positional framings changed. The findings showed that students' positioning as collaborative contributors was facilitated by one student's repeated attempts to elicit other students' reasoning, which reflected her framing of herself and others as collaborative contributors. Although, at first, the other students persisted in framing themselves as acceptors of knowledge from an authoritative provider, this student was able to transfer her framing of the interaction that was separate from the authoritative provider, and the students began to acknowledge one another as contributors who could jointly develop their own reasoning. I suggest that to form a community of collaborative contributors in argumentation activities in science classrooms, it is important for students to not only actively make their individual voices heard but also frame one

another as potential contributors. Additionally, the findings showed that student agency played an essential role in facilitating this shift. I discuss the meaning of being collaborative contributors, rather than simply a group of individual participants, in argumentation from the perspective of positional framing, and I consider the instructional implications of the study results.

4.2 Chapter Introduction

With an emphasis on *doing* science, scientific argumentation has been gaining attention as a core epistemic practice to construct communal knowledge (Driver *et al.*, 2000; Kuhn, 2010; NGSS Lead States, 2013). Many studies have explored how argumentation activities are implemented in science classrooms by examining various features of students' practices and instructional support to facilitate the collaborative development of communal knowledge (e.g., Jimenez-Aleixandre & Erduran, 2007; Osborne *et al.*, 2004; Sandoval & Millwood, 2007; Von Aufschnaiter *et al.*, 2008).

As discussed in this literature, engagement in scientific argumentation involves individuals collaborating as rational agents to construct valid arguments that can make sense of given phenomena (Nielson, 2013). However, when students perceive argumentation activities to be in line with the didactic instruction that they are used to, they do not assume the roles of producing and evaluating arguments in the discussions when argumentation activities are implemented. This indicates that we need to understand students' epistemic understandings of argumentation activities, how they understand that knowledge to be constructed in an argumentation activity, and what they need to do in the specific context of the activity (Hutchison & Hammer, 2010; Rosenberg *et al.*, 2006; Sandoval, 2005).

Many studies have explored students' understanding of argumentation activities as reflected in their practices (Berland & Hammer, 2012; Ryu & Sandoval, 2012; Sandoval & Millwood, 2007). Furthermore, several studies have explored contextual cues that facilitate shifts in students' epistemic understandings of sense-making discussions in science classrooms (e.g., Hutchison & Hammer, 2010; Louca *et al.*, 2004; Rosenberg *et al.*, 2006). The contextual cues described in this research are those that validated students' ideas by enabling the students to contribute to the process of developing a reasonable argument. Thus, the cues encouraged students to perceive that their practices were acknowledged in the activities in which they were participating, thereby shifting their epistemic practices.

These contextual cues have been delineated in the literature alongside descriptions of students' active participation in discussion and have been described as one of the key aspects of facilitating shifts in students' framings of argumentation. While observing students' epistemic practices in the context of these types of contextual cues, I noticed that some students began to actively participate in discussion, but most of the students remained in passive positions. Even in many of the groups that shifted to collaborative discussion, the shift did not occur suddenly. I noticed that there was a process of students transferring and negotiating their framings in discussion as they positioned themselves as collaborative contributors to the development of communal argument. Based on these observations, I developed the following two questions. First, how do students not only shift and frame their roles as contributors to knowledge development but also share that framing with one another? Such cues can lead students to change their epistemic understandings of argumentation activities; however, these cues are

unlikely to be interpreted in the same way by all students simultaneously since there are various possible interpretations of the same situation (Goffman, 1974). Therefore, students may need to negotiate their different framings with one another during interactions in the context of these cues.

Second, how do students enable one another to engage in the development of arguments? Engaging in collaborative knowledge-making discussions encompasses not only participating as rational agents but also acknowledging one another as rational agents. Specifically, in students' interactions, it is necessary for them not only to propose diverse ideas but also to listen to others' ideas and consider those ideas in their construction of arguments. Considering these aspects, I expected that the contextual cues described in the literature would trigger students' intentions to actively engage in discussions in which they would transfer their framings of their and others' epistemic roles, thus aligning their emergent framings as collaborative contributors.

Although shifts in students' epistemic understandings have been discussed in previous studies, an understanding of how a group of students aligns their shifted perceptions of an activity through a discussion is still lacking. Since discussion between multiple participants within a social domain is a key feature of scientific argumentation, a shift in one student's epistemic understanding is not sufficient; it is necessary for the students in the group to align their framings of the activity (Berland & Hammer, 2012; van de Sande & Greeno, 2012). However, as it is unnatural for students to align their perceptions of an activity, they need to negotiate their roles as collaborative contributors to the development of knowledge through their interactions with each other.

The findings of this study contribute to the previous literature that has explored shifts in students' epistemic understanding by adopting a positional framing perspective and analyzing how students negotiate their personal understandings of their positions in an argumentation activity. To capture students' understandings of their roles that dynamically shifts in their interactions, I used the theoretical perspective of framing (Bateson, 1972; Goffman, 1974; Tannen, 1993). This perspective has been adopted in the literature in science education to discuss context-sensitive dynamics of students' epistemic practices and epistemic understandings (Berland & Hammer, 2012; Hutchison & Hammer, 2010; Redish, 2004; van de Sande & Greeno, 2012). Furthermore, I investigated how the negotiation of framing has been facilitated and describe how student agency plays a key role in this discussion. Specifically, I asked the following questions in this study:

(1) How do students shift their personal framings of their positions in an argumentation activity?
(2) How is a shift in shared framing facilitated in a group?

4.3 Framework for Analysis

This study aimed to explore how students acknowledge each other as collaborative contributors in the development of communal arguments through discussion. To address this research problem, I especially focused on the transference and negotiation of students' positional framings in their discussions. To explore more precisely how participants negotiate positional framings in interactions, I analyzed students' positional framings based on the following framework.

4.3.1 Positional framing

To explore how students negotiated their positions in response to each other's practices in their interaction in argumentation activity, I defined and used the perspective of positional framing, which means that I focused on how students framed themselves and one another as capable of contributing to the construction of communal knowledge arguments. Highlighting the relative aspect of student positioning, in addition to the features of positional framing that have been discussed in previous studies, I considered another aspect of student interaction—the boundary of the interaction—as described below.

4.3.2 Consideration of the boundary of interaction in students' positional framing

Saying that someone has been framed as holding a particular relative role implies that a process of comparison between participants' different roles has occurred consciously or unconsciously (Levine, Resnick, & Higgins, 1993). Comparisons can be made of the position of participants who engage in interactions, not just a group of people who are seated together around a table. In other words, positions are compared between participants who engage in interactions, and the physical proximity of the students alone cannot indicate whom they have actually perceived as the participants in their discussion. To address this notion, I drew on the concept of zones of interaction, which Shepardson and Britsch (2006) defined as "frames or boundaries for describing the nature of teacher–child interactions that evolved during the science activity" (p.450). They developed this concept based on Vygotsky's zone of proximal development (1978,

1986), exploring how a teacher interacts with certain students and forms an area distinct from that around other students. Expanding the definition beyond teacher–student interactions, I modified the definition of zones of interaction to refer to boundaries around students who are interacting with each other so that I could describe between whom actual interactions occurred in a certain group. In addition to adopting this concept, as mentioned above, I intended to distinguish different patterns of interaction and negotiation of positional framing among the students whom I studied.

To explore how students negotiated their positions when their practices shifted into collaborative meaning-making discussions, I construed positional framing as students' expectations of themselves and one another within the zones of interaction in which they developed communal arguments. Then, I explored students' perceptions of who possessed knowledge and who could contribute to the construction of arguments, which could alter when their zones of interaction changed. Additionally, I observed different patterns of interaction that the students showed as a group. I expected that the consideration of students' positional framings in their zones of interaction would help explore students' positional framings by addressing its relative features.

4.4 Research Context and Methods

To understand how students negotiated the framing of their and each other's positions as collaborative contributors in argumentation, I chose a case study method for the analysis. According to Sharan Merriam (1998), the case study is a qualitative research method to gain an in-depth understanding of a situation. The case study is differentiated from other types of qualitative research methods in

that it focuses on the analysis of a bounded system (Merriam, 1998). In this study, I purposefully selected a group of students who clearly demonstrated the negotiation of framings and used a qualitative case study approach to investigate their interactions. I examined students' personal framing of their positions in argumentation activities and their transfer and alignment of their framings of themselves as contributors in the co-construction of communal knowledge claims.

4.4.1 Research participants

The school is located in a socioeconomically middle-class area in Seoul, South Korea. The students' grades were at an average level in South Korea. One science teacher, Ms. K, and 37 seventh-grade students participated in this study. The participants were told that they could choose not to participate in this study and that there would be no negative consequences of choosing not to participate. After this introduction to the research participation, the participants consented to take part in the study by signing the consent form that was confirmed by Institutional Review Board in Seoul National University (IRB No. 1304/001-043).

The students' science classes were held in a laboratory with tables of four to five students; thus, the students could engage in small-group activities. I chose one group of four students as the focus group for the study. Their seating arrangement, shown in Figure 2, was decided by Ms. K and was designed to support discussions in an amicable atmosphere in each group based on the student relationships she had observed.

When interviewed, the students in the focus group told the researcher that they had previously experienced both didactic and experimental lessons in Ms. K's

typical classes. When asked which type they preferred, most students chose the lessons with experiments, citing various reasons, such as “because it helped us to understand key concepts [which are suggested in the national curriculum],” “[because it helped] to memorize these concepts more easily,” “because we can talk more freely” and “because we can do hands-on activities.” These responses show that the students preferred active participation in diverse epistemic activities but still perceived the goal for these activities to be to accumulate knowledge of scientific concepts. It can be inferred that the students framed the science classroom as a context in which correct answers were emphasized, and they participated in experimental lessons with this framing. This observation was also supported by the students’ initial dependence on Hyun, who they perceived to hold higher epistemic authority even in argumentation activities. However, the students’ discussion showed context-dependent shifts in their framings, which is one of the reasons that this study focused on this group.

Figure 2. The seating chart of the focus group

4.4.2 Research context

Ten argumentation activities about concepts related to plants and photosynthesis were designed and implemented in the participating classroom (Appendix 1). The activities were designed to facilitate students’ active

participation in dialogical discussion and to support a shift in their framings. More specifically, the activities were designed to encourage students to propose alternative knowledge claims and participate in discussion to develop a consensual argument. In the first lesson, before beginning the argumentation activities, the students were introduced to argumentation and the components of an argument. Then, they were asked to establish rules for the following argumentation activities in each group. This lesson was intended not only to support the students in proposing possible norms for their activities but also to engage them in argumentation by evaluating the validity of each idea as a proper norm. In the following lessons, the worksheet on which the students wrote down the rules they established were placed on the students' table and was occasionally referred to by the teacher in class or by the researchers in the interviews to facilitate the students' reflection on their practices based on the rules they had established. This supported the students in following those rules in their discussion and developing their own norms for participation in argumentation activities. The first lesson was followed by argumentation activities about the different concepts. Each activity explored different phenomena related to the concepts of plants and photosynthesis, such as the function of plant roots, the transportation of water through xylem, and girdling. To facilitate discussion focused on the development of reasoning and critical evaluation, the activities were designed with explicit questions asking the students to construct arguments with valid justifications, evaluate them through discussion, and reach a consensus in each group. Information about the phenomena was provided on the students' worksheets so that the students could make observation and use the information as evidence to support alternative claims. This aspect allowed the students to support different claims and elaborate their reasoning

through discussion, which facilitated the students' engagement in the social meaning-making process.

In the eighth lesson, which was the main context of the discourse analyzed in this study, the students were asked to discuss a specific phenomenon related to bean germination. A picture showing two beans—one with no water (Bean A) and one germinated by being submerged in water and then dried (Bean B)—was given to the students. Then, the students were asked to develop an argument regarding which bean would be heavier and to support their argument with valid reasoning. The students were asked to construct individual arguments first so that they could later share and consider the diverse individual ideas in group discussion. Then, to facilitate critical evaluation of the ideas and sophisticated reasoning in the group discussion, the students were asked to develop an agreed-upon argument in each group. Brief explanations of concepts relevant to cellular respiration and germination were provided on student worksheets called evidence cards so that the students could consider these concepts in their reasoning, which would facilitate discussion.

The argumentation activities were introduced to the teacher before she implemented them in the science classroom, and the design of the activities intended to facilitate students' engagement in dialogical argumentation was highlighted. The teacher included the argumentation activities in her seventh-grade science class's syllabus, providing sufficient time for students' group discussion in each activity. She introduced the group discussion to the class, emphasizing active participation in discussion. During group discussions, she visited each group and tried to facilitate students' presentation of their own ideas in discussion.

4.4.3 Data collection and analysis

Data collection

Each group was recorded on audio and video; observations were also recorded in field notes. The groups that showed active interactions were selected and semistructured interviews were conducted with them after each lesson. The interview questions focused on the students' reflections on their practices and their cognitive understanding of the main content of the activity. In the interviews, to explore students' thoughts on their own practices in argumentation activities, the recordings of the students' discourses were reviewed to investigate whether and how they reached consensus in group discussion. The interviews were also recorded, and the discursive practices in the recordings were transcribed for more detailed analysis.

Data selection

As mentioned above, to understand how the students negotiated the positional framings of themselves and one another as collaborative contributors in the context that facilitated their active engagement in discussion, I purposefully selected a group that clearly demonstrated this negotiation in their discursive practices. I watched the videos of each small group practice and read the transcripts iteratively.

Then, the focus group for this study was selected based on the following criteria. First, the students' practices needed to reflect a shift from dependence on epistemic authority to engagement in discussion to contribute to the development of and consensus on arguments. Second, the students' zones of interaction and

positional framings needed to be clearly revealed in their discourses and behaviors during argumentation. With regard to positional framing, a small group whose discourses revealed their relative epistemic authority and their expectations of how each participant would contribute to the construction of their justification was selected. Third, I examined whether students' discussions contained dialogical features (Ford, 2012; Kuhn, 1991), which were identified based on certain discursive practices, such as proposing diverse ideas to the entire group and exchanging critical evaluations of these ideas (Nielson, 2013; Shepardson & Britsch, 2006).

In reviewing the video of the focus group practices and the transcripts, the researchers identified those parts of the discussion that clearly showed the students' positional framings and alignment of framings as collaborative contributors. The interview transcripts were also used to understand their practices and infer their framings, especially regarding their interactions and roles, which changed dynamically depending on the context and the type of interaction. Framing negotiation during discussion was observed more frequently in later lessons; therefore, the present study focuses on the eighth lesson, which was about the cellular respiration of beans, as elaborated above.

Data analysis

The analyzed data consisted mostly of discursive practices that were explored through the videos and transcripts. As described above, I inferred students' relative positions based on their cognitive contributions to the construction of their group's arguments. The transcripts of the interviews with the students were also used to infer their framings and to support the analysis of the

students' discussion in the science classroom. To analyze the students' positional framing, I first divided the context of the students' discourses into the key conceptual ideas used to develop their reasoning in the discussion. Then, the students' zones of interaction were investigated as boundaries of comparison for their positions. By defining the zones of interaction as boundaries around students who interacted with, the students' responses to each other formed the center of the analysis of the zones of interaction. To investigate who engaged in the discussions as contributors in the development of reasoning, I used the following criteria to classify different zones of interaction: (a) which students were interacting with each other and (b) which students were providing ideas to develop reasoning. The students who were listening to the speaker's words, although they might not have been replying verbally to the speaker, were considered to be interacting since they were engaged in the exchange of cognitive ideas. However, when a speaker talked to someone specifically, asking the listener for his or her words, and the others did not intend to engage in the conversation, I considered the interaction to be separated from the others. These criteria were modified from those originally suggested by Shepardson and Britsch (2006). Based on these criteria, the zones of interaction were classified as follows (Figure 3): (a) a separate zone of interaction—when only two students were talking to each other and their conversation was directed only to each other at the time; (b) a collective zone of interaction—when students' talk was directed to more than two students in the group; or (c) a polarized collective zone of interaction—when the students were interacting, but only two students were mainly presenting their ideas in the discussion to develop the reasoning for each key conceptual idea, with the others as mere listeners.

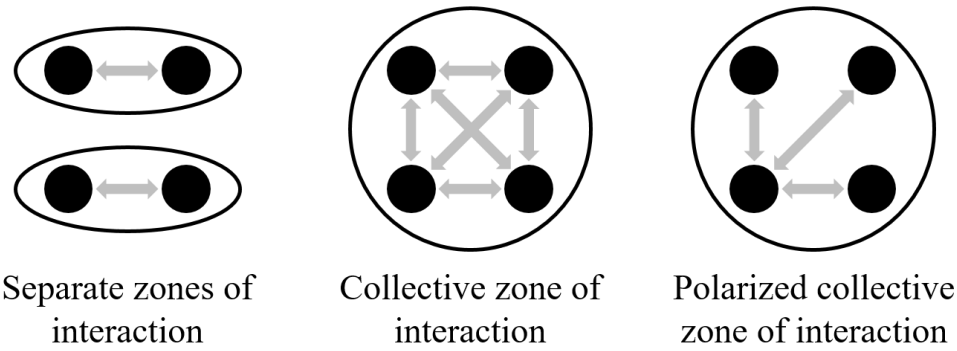


Figure 3. Simple images depicting the interactions among the students in each zone of interaction

Then, the students' positional framings within these zones of interactions were inductively drawn out through iterative analyses of the data (Miles & Huberman, 1994). To analyze the students' positions, I first followed the binary division suggested by van de Sande and Greeno (2012), which describes the way the students contributed to the construction of communal knowledge as either sources or listeners. Specifically, based on the flow of cognitive information, each student who suggested a conceptual idea to construct a line of reasoning was coded as a source and each student who responded to the idea was coded as a listener. Beginning with this broad categorization, I intended to capture the way that students coordinated their roles with one another in discursive interaction.

While exploring the initial coding of the discourses, I noticed that not all ideas or responses to the suggested ideas were acknowledged as valid issues for discussion. Since being a collaborative contributor in scientific argumentation implies not just speaking about an idea by oneself but jointly sophisticating arguments and justifying their validity (Ford, 2012; Kolstø & Ratcliffe, 2007), this aspect was interpreted as indicating recognition of the person with the idea as a

contributor in the zone of interaction. I subdivided the initial coding based on whether and how the students contributed to the development of reasoning in their zone of interaction and tried to answer the following questions based on their discursive practices: (a) Did the listener expect an idea that the potential source provided to be definitive or one of the possibilities? (b) How definitive was an idea that the source proposed? (c) How did the source expect the potential listener to respond to an idea he/she proposed? (d) How did the listener respond to the proposed idea? I inferred what the students expected from each other and compared it with other students' framings within each zone of interaction to identify discordance or alignment between their positional framings. I referred to not only the cognitive ideas that were delineated in the discourses but also tone of voice; facial expressions; and, in case of questions, the kind of response that was expected.

The codes for the positions that were inductively identified and the representative excerpts for each position are shown in Table 2. The students framed themselves as potential contributors, presenting cognitive ideas to develop reasoning and expecting these ideas to be evaluated, but their framing of one another differed depending on the epistemic authority they expected and the zone of interaction they were in.

Specifically, first, in the polarized collective zone of interaction, students' showed framings of one another's positions as authoritative sources or acceptors, depending on the expected epistemic authority of the participant. One student who provided ideas in a conclusive manner was perceived by the other students as holding higher epistemic authority than the others. I coded this student as an "authoritative source." She responded to the other students' ideas with assessments of their "correctness," and her tone implicated listeners to accept her ideas with no

Table 2. Categorization of student positions in the zone of interaction, with descriptions of each practice

Perceived epistemic authority of a participant	**Positions of the participant**	
	Polarized collective zone of interaction	**Separate zone or collective zone of interaction**
Participant with higher epistemic authority	Authoritative source • Provides ideas in a conclusive manner that is interpreted to indicate no need for further validation • Assesses the 'correctness' of the presented ideas	Collaborative contributors • Propose ideas that need further validation • Elaborate on the proposed idea by critically evaluating its validity or adding more reasoning
Other participants who previously depended on the participant with higher epistemic authority	Acceptor • Not considered to propose ideas that need to be discussed • Accepts ideas proposed by the authoritative provider without his/her own evaluation	

evaluation of their validity. For the other participants in the polarized collective zone, their ideas were not taken for critical evaluation and the participants were considered mere listeners. I coded this position as an "acceptor." In the separate zone and collective zone of interaction, I found that the students' framings of one another's positions shifted. The students' interactions shifted such that the source proposed an idea upon which a listener elaborated, developing the idea into a more valid argument. The students frequently shifted between being a source and a listener, proposing ideas and critically evaluating its validity or contributing additional reasoning. I coded this position as "collaborative contributors."

Based on the results of the coding, I explored how the students participated in interactions and negotiated their positional framing, and I describe the understanding of the selected parts of their discussion in the next section. I aimed to establish the credibility of the coding and analyses through triangulation of the data sources and consensus among the researchers regarding the interpretation of the students' practices (Merriam, 1998). Specifically, the recordings of the classroom discussions, the interviews, and the field notes taken during the activities were compared.

4.5 Findings

In this section, I describe the case I analyzed, in which the students transferred and negotiated their positional framings of themselves and one another as they reached alignment in their framings of their positions as collaborative contributors in a context that encouraged them to shift away from being passive recipients of authoritative information. I organize this section based on the three different zones of interaction that occurred in the following order: a polarized collective zone, a separate zone, and a collective zone.

4.5.1 A polarized collective zone of interaction with discussion centered around Hyun

Although the students suggested their ideas and engaged in interactions, their interactions at first were typical in that Yeon, Jeong, and Min showed dependence on Hyun, whom they perceived as holding a higher epistemic authority. Although it seemed that the students were sharing their ideas with each other, Hyun and one of the other students were mainly participating in the discussion, so I

coded this zone of interaction as a polarized collective zone. This was typified in the discussion when Yeon, Jeong, and Min looked at Hyun when suggesting their ideas, indicating that their interactions were focused on Hyun and that they framed Hyun as a listener who could contribute to the development of their cognitive ideas.

The students' interactions with Hyun could not be described as the conversations of collaborative contributors. The students focused mostly on suggesting their ideas to Hyun and asking her to confirm the validity of their ideas. Based on Hyun's responses, they gave up on their idea or insisted on it despite the rebuttal rather than revising their reasoning or making a more sophisticated argument. In the discourse shown in Table 3, when Yeon suggested a justification based on whether water was poured on Bean B (line 106), Hyun rebutted the idea concisely, referring to the experimental procedure of removing water from the bean and elaborating on the intention behind the procedure (lines 106, 109). However, the other students continued to reveal their skepticism about the complete removal of water from the bean with no modification or additional reasoning (lines 111, 114, 118). I inferred that they considered Hyun's approval of the "correctness" of their ideas to be validation and were attempting to support their idea through the authority held by someone else (Sandoval & Millwood, 2007). Therefore, it seemed that the students interpreted Hyun's rebuttal, even though Hyun provided the experimental procedure as evidence to justify it, as dismissal and showed limited reasoning. I inferred that this feature of the students' discussion showed their framing of Hyun as an authoritative source, while they framed themselves as contributors.

Table 3. Discourse between the students in the polarized collective zone of interaction

Line	Speaker	Discourse
87	Jeong	I mean, how much water does it lose . . .
88	Yeon	(While looking at Hyun) Hey, then . . .
89	Jeong	(Looking at Yeon, in an irritated tone) I spoke first.
90	Yeon	I didn't hear that.
91	Jeong	Listen to what others say. Anyway, it's . . .
	. . .	
106	Yeon	(Looking at Min) Oh. (Looking at Hyun) Hey, since we are pouring water on this one [Bean B], won't this one become heavier?
107	Hyun	But it dries up afterward.
108	Yeon	Dries up?
109	Hyun	Because the intention was not to pour water on it but to facilitate its germination.
110	Yeon	Oh.
111	Min	But how does it dry up without any light?
112	Yeon	(Looking at Hyun) Aren't they the same [weight]?
113	Hyun	I just said that it dries up.
114	Min	But they poured water on it.
115	Jeong	No, they didn't.
116	Hyun	I'm saying that they didn't pour any water. This one sprouted and then dried up for three days.
117	Min	Oh.
118	Yeon	But still, it might not get rid of all the water in it (laughs).
119	Hyun	That's just your opinion.
120	Min	But Bean A could be heavier.
121	Hyun	That's what I said.
122	Min	Um, I don't understand (in a frustrated tone).
123	Hyun	Well, I don't get it either. Maybe they weigh the same.

(( )): Inaudible part of the recordings.
. . .: Omitted part for readability.
[ ]: Inferred meaning by the researcher based on the collected data.
( ): Tone of voice, facial expression, or gesture of the speaker.

Hyun did not attempt to propose her ideas to the other students but engaged in the discussion by responding to the other students' ideas. Hyun's responses could have been based on critical evaluations of the other students' ideas, which implies that she could have framed her position as a collaborative contributor. However, her words did not successfully convey to the other students

why their idea could not be valid; therefore, her comments appeared to them to be assessments of their ideas. Furthermore, in the interview, Hyun revealed her skepticism regarding the other students' ideas based on her perception of their limited capability to provide valid ideas, saying: "I couldn't accept the idea [that Min proposed] because she wasn't really aware of what she was talking about." Additionally, when one researcher asked her why she did not accept the other students' ideas, she responded: "Because her [Jeong's] idea is quite fabricated . . . without any evidence provided." Hyun's practices and interviews indicated her assessing attitude toward the other students' ideas and that she framed herself as an authoritative provider who examined the other students' ideas, which she believed could not have been correct and would need to be revised.

The students barely included each other, except for Hyun, as valid contributors to their discussion. This was especially noticeable in the discourse in which Jeong blocked other students from talking to Hyun and tried to share her idea exclusively with Hyun (Table 3, lines 87–91). Not only did Jeong focus on talking to Hyun, but Jeong also ignored Yeon's comments and tried to push her idea into the interaction with Hyun instead. Jeong's practices indicated that she did not frame Min or Yeon in a position that could contribute to developing the ideas that Jeong suggested but rather considered them acceptors in their zone of interaction. When a researcher asked why they did not talk to each other except to Hyun, Jeong explained: "I would have trusted their [other students'] ideas if they were the top students [in terms of their grades] at the school." The students' distrust in each other, based on their grades, led them to position themselves and one another as just acceptors or not even as valid contributors in the interaction. This response implied that the students did not accept each other's ideas if they were uncertain

without trying to examine their validity; rather, they relied on Hyun's judgment of the validity of their ideas.

Meanwhile, Min made several attempts to change the existing features of the interactions. She showed her intention to accept other students' ideas and discuss them, which indicated her framing of herself and the others as proposer and critical evaluator. In the discourse, for example, she questioned Hyun's explanation of the loss of moisture of the beans (line 111), trying to join the interaction between Hyun and Yeon. However, Yeon did not listen to Min's discourse and moved directly to a revision of the claim based on Hyun's rejection. Dismissing her idea immediately after Hyun's rebuttal and attempting to seek an answer, Yeon revealed her persistent dependence on Hyun. Min's question was discouraged again by Jeong (line 115), who said that water was not poured on Bean B. Therefore, although Min tried to share her positional framing of the group members as proposer and critical evaluator, Yeon and Jeong resisted shifts in their positional framings owing to their strong reliance on Hyun's epistemic authority. Min also recalled this discourse as her attempts being rejected by other students: "When I talked about something that I did not completely understand, the other students didn't acknowledge it as a potentially valid thought."

In this zone of interaction, the students interacted with one another, but the interaction was mostly between two students, and the others were not involved in the development of reasoning. It was difficult to say that they developed communal knowledge in this zone since the chain of reasoning was short and mostly ended with disagreement between participants. However, the students did not remain passive recipients of knowledge, as typically occurring in a classroom with high reliance on epistemic authority. They tried to express their thoughts,

which could be interpreted as framing themselves as relatively active participants compared to the passive recipients typical of traditional classrooms. Nevertheless, they showed limited acknowledgment of one another as other collaborative participants in their discussion, except for Min's delineation of her positional framing of herself and other students as critical evaluators. These features led me to consider this zone a polarized collective zone rather than multiple separate zones of interaction.

4.5.2 Elaboration of ideas in a separate zone of interaction from Hyun

Although the other students had blocked Min's attempts to participate in their zones of interaction and expand the reasoning in the polarized collective zone of interaction, Min was the one who later facilitated the shifts in positional framing. She facilitated a separate zone of interaction with Yeon, where she was able to share her positional framing as a collaborative contributor. This change began when Yeon brought up another line of reasoning regarding cellular respiration based on one of the evidence cards, thereby starting a new discussion:

Yeon: Plants always do respiration? What does it have to do with this phenomenon?

Hyun: Because it loses weight when nutrients get decomposed by respiration.

Yeon: Oh.

Afterward, the discussion paused. The students looked at their own worksheets, and it seemed that they were thinking individually. Then, Min resumed the discussion by asking Yeon—not Hyun—for more details about the contents of the evidence card on cellular respiration (Table 4, line 127). It was the

Table 4. Discourse between the students in the separate zone of interaction from Hyun

Line	Speaker	Discourse
127	Min	Hey, what is that (pointing at one evidence card) supposed to mean?
129	Yeon	It means that a bean loses weight when nutrients are decomposed.
130, 132	Min	Oh, really? . . . But then, is this one with nutrients decomposed?
136	Yeon	What was it called, umm, the nutrients are decomposed when plants do respiration?
137	Min	So, this one has decomposed nutrients?
138	Yeon	Yeah.
139, 150	Min	But there's no light here. Oh, never mind. (Pause) Hey, Yeon, but why does it need evidence that says a lot of energy is needed when the beans germinate?
151	Yeon	Where?
153	Min	It's not necessary. If they used the energy . . .
154	Yeon	Isn't it, like, if energy goes out when it is needed, then the weight decreases?
155	Min	Why?
156	Yeon	Because it uses the energy just like us doing exercise, using the energy, and losing weight.

first time that a zone of interaction without Hyun was formed, which emerged from Min's attempt to understand the evidence on the card. At the same time, Jeong asked Hyun about the relationship between the amount of energy used and the weight of the beans, and the discussion in the group proceeded into two separate zones of interaction. Considering the students' perceptions of Hyun's epistemic authority and Jeong's exclusion of the other students from her interaction with Hyun, Yeon seemed to be the best prospect for Min to transfer her positional framing of the group members as collaborative contributors. I inferred that Min's initiation of the separate zone was possible because Yeon was the one with whom she initiated this interaction.

In the beginning of Yeon and Min's zone of interaction, Yeon persistently relied on Hyun's epistemic authority, but Min tried to elicit Yeon's explanation, reflecting her positional framing in these discourses. For example, Yeon responded to Min's question that aimed for meaning-making, but it was a mere repetition of what Hyun had told her earlier (line 129). This response indicated that she had framed Hyun's position as an authoritative provider and had been influenced by Hyun in the previous polarized collective zone. However, Min was not content to accept that response; she continued to ask for a detailed reasoning and explanation behind Yeon's words. She also tried to apply Yeon's explanation to the given phenomenon (lines 130, 132, 137). Min's discourse indicated that she was framing herself as capable of developing valid reasoning about the given phenomena. Furthermore, it implied that Min had recognized Yeon as another contributor who would work as a facilitator, considering the validity of arguments together with Hyun in the polarized collective zone. Additionally, by applying the information provided by Yeon, Min showed her trust in Yeon as a valid source in this knowledge-building activity. Therefore, Min constantly reflected her framing of Yeon and herself as collaborative contributors in her discourse.

Consequently, Yeon showed discursive practices indicating a shift in her positional framing, which aligned with that of Min. In line 150, Min asked a question based on another evidence card, which led to a development of the group's justification of the usage of energy during germination. Yeon then suggested a relationship between the usage of energy during germination and a decrease in the weight of the bean, linking the contents of the evidence card to the relevant claim that could be explained by it (line 154). Min asked "Why?" again, facilitating Yeon to elaborate on the reasoning behind that idea to persuade Min.

Then, Yeon mentioned her everyday experience and elaborated on her reasoning (line 156). During the discussion, Yeon brought up more diverse ideas, using evidence cards, and Min continued to ask Yeon to help expand their collective reasoning. This exchange led to the development of their understandings of cellular respiration and improved the sophistication of their argument as they elaborated, in their own words, on the justification that Hyun had briefly mentioned.

The separate zone of interaction between Yeon and Min was initiated by Min, who was trying to understand the key concept that Yeon had raised. Their positional framings were not aligned at first, but they reached alignment in their framings through Min's constant requests for Yeon's reasoning, which allowed them to develop an argument with elaborated reasoning about the concept of cellular respiration. This positional framing, with Yeon and Min as collaborative contributors, had not been present in the previous polarized collective zone with Hyun. This interaction also contrasted with the zone of interaction between Hyun and Jeong. In this zone, Jeong asked Hyun how the weight of the bean would change when the energy was used, and their interaction ended when Hyun answered the question. The disparate features of the interactions in these two separate zones indicated that the formation of the zone of interaction in which Min's positional framing could be transferred to another participant was a key initiative in the shift in the students' positional framings to collaborative contributors.

At the end of their separate zone of interaction, Yeon and Min wanted to confirm their reasoning, so they asked Hyun and Jeong for their thoughts, attempting to expand their zone of interaction into a collective one.

Yeon: (Looking at Hyun) Hey, hey, do our weights drop when we use lots of energy?

Min: (Looking at Jeong) Does it weigh less if they use lots of energy?

Hyun: When it uses more energy, more nutrients would be . . .

Yeon: Okay, I'll go with Bean A [, which weighs more,] then.

When Hyun repeated their reasoning, Yeon became confident in their rationale and the claim based on it. This exchange contrasted with the pattern of discourse in the earlier polarized collective zone of interaction.

However, the discussion did not instantly expand to the collective zone, as Hyun asked Ms. K to confirm whether the beans also respire, relying on the teacher's authority rather than discussing the question with the other students. The students' discussion showed the formation of a separate zone of interaction several times afterwards and then an expansion to the collective zone of interaction at the end of the discussion.

4.5.3 A collective zone of interaction with collaborative contributors

At the end of the discussion, the students formed a collective zone of interaction and revisited the reasoning based on the water content in the beans. In contrast to the previous discussion on the same topic, they started to justify their claim with their ideas about the structure of beans and their everyday experiences, despite Hyun's rebuttal (Table 5).

In this discourse, although the topic of the discourse was not what this study had initially intended it to be, the students revisited the idea that they had proposed earlier and collaboratively made their arguments more sophisticated. The students proposed their ideas, shared critical evaluations with each other and

complemented their arguments. Jeong again raised a justification of the water content, complementing her idea about the structure of the beans (line 302, 304). Since Hyun had constantly rebutted this idea, she gave a tired groan (line 303) and stepped back from the discussion.

The students discussed their own ideas despite Hyun's rebuttal, indicating that they considered their voices and ideas to be as valid as hers and reflecting their framing of the activity as "making sense of phenomena," as per Lemke (1990). Yeon conceded the potential of Jeong's idea (line 305), facilitating the further expansion of the discussion with the other students. Min then elaborated on Jeong's idea, justifying her thought based on the length of the period of dehydration (line 313). Since the reasoning based on the procedure had been continuously rebutted before, Yeon and Jeong rebutted Min's reasoning (lines 315, 317), which was also their previous idea. Jeong's rebuttal led Min to develop the justification with a hypothetical case of people not drinking water (line 318), but Jeong rebutted this suggestion by arguing that people would be dead by then. This discourse showed that the students critically evaluated their own ideas by listening to each other's voices. Based on these practices, it could be inferred that they framed their positions as collaborative contributors, whose proposed ideas could be acknowledged as valid to develop their arguments.

Hyun also engaged in the interaction, rebutting the reasoning about the water content by saying that the water had dried to the same level in both beans (line 326). Her idea was not a scientifically canonical one either, but I conjectured that she wanted to indicate that the water content of both beans was irrelevant to the change in their weight. Hyun's intention was explicitly mentioned in the interview, in which she described the justification of the water content as

"fabricated." In the discussion, Yeon copied Hyun's words, which indicated the other students' acceptance of Hyun's intention. Their discussion was closed as the students agreed on the validity of the reasoning regarding the water content of the beans despite Hyun's rebuttal.

In this discourse, they critically evaluated the idea with their own words and shared the reasons that the idea was not valid by rebutting its flaws, thereby developing the argument with an additional qualifier of the claim. Although the students again dismissed the idea of water content at the end of the discussion, they acknowledged that another student's idea "could be a valid argument as well" (line 337). Their discussion advanced their reasoning by including the concept that "Bean A would be heavier if the beans were completely dried up after they were soaked to sprout." I highlight this feature since it shows the students' changed their epistemic understandings of their practices and explicitly acknowledged their own and one another's positions as contributors to the discussion.

In summary, the students' shift to collaborative contributors started with Min's agency, specifically, the shift in her positional framing and her attempts to transfer the shifted framing to the other group members. This led to the frequent formation of separate zones of interaction without Hyun, who held a relatively higher epistemic authority. They then engaged in practices that reflected their framings as proposers or facilitators, with the other students acknowledging the validity of their ideas and not just those of Hyun. This shift facilitated them to add their voices and experiences to the discussion, jointly developing valid arguments. Then, at the end of the activity, even in a collective zone of interaction with Hyun, the other students also engaged in the discussion and showed the development of more sophisticated arguments.

Table 5. Discourse between the students in the collective zone of interaction

Line	Speaker	Discourse
302	Jeong	Can I suggest another weird idea? If it dried up only on the exterior part because of its peel, then the inside might not be dried up.
303	Hyun	(In an annoyed voice) Gosh.
304	Jeong	If it didn't dry up inside, then, it could be heavier.
305	Yeon	(Agreeing with Jeong's idea) Yeah, that's possible.
306	Jeong	(Looking at Min) Hey, I'll add another claim to your arguments. If this one didn't dry up because of the peel …
. . .		
313	Min	But, if Bean A was put in a place with no light and no water, so it didn't sprout, it means that it has been drying out since then. But if Bean B was getting water in the earlier stage and then dried up, it could be possible that there's still some water here [in Bean B].
314	Yeon	Then there could be a little bit of water here [in Bean A] as well.
315	Jeong	But isn't it dried up for three days after it sprouted by pouring water?
316	Min	Yeah, but isn't it possible that there's water inside?
317	Jeong	But they were dried up for three days. Oh, yeah, it could be possible.
318	Min	We have water inside our bodies even if we don't drink water for three days. (laughs)
319	Jeong	But Hyun just said that we should consider these almost dried up. There could be hardly any water left in there after drying out for three days.
320	Min	But it's still possible.
321	Yeon	(To Hyun) But it dries up more slowly without light.
322	Jeong	Could you stand being without any water for three days?
323	Min	Sure.
324	Jeong	People cannot live without water. Without food, it may be possible for seven days. But without water, I guess, two days?
. . .		
326	Hyun	But the amount of water that dried up is the same in these cases.
. . .		
328	Yeon	Yeah, right. The amount of water that dried up is the same in these cases.
. . .		
337	Jeong	(To Min) I think yours could be a valid argument as well.

4.6 Discussion

In contrast to the expectation that students will actively engage in a joint effort to construct knowledge claims when argumentation activities are implemented in science classrooms, recent studies have found that many students do not suddenly engage in productive discussion or gradually advance their work but dynamically shift their epistemic understandings and practices (Berland & Hammer, 2012; Louca *et al.*, 2004; Russ *et al.*, 2012). Furthermore, studies have empirically delineated various contexts in which students changed their epistemic practices and became active participants in discussion to make sense of natural phenomenon (Berland & Hammer, 2012; Greeno, 2009; Hutchison & Hammer, 2010; Rosenberg *et al.*, 2006). Based on these findings, this study implemented argumentation activities that were designed to facilitate students' engagement in dialogical argumentation in a seventh-grade science classroom. Based on the notion that students negotiate their personal positional framings through various interactions with each other to develop communal arguments (van de Sande & Greeno, 2012), I investigated changes in the students' interactions. I specifically investigated how the students acknowledged not just themselves but also one another as participants who could collaborate together to develop arguments in discussions. In this section, I describe how the findings of this study further our understanding of students' positioning as collaborative contributors in argumentation activity and how student agency plays a key role in facilitating this change.

4.6.1 Discussion in the polarized collective zone of interaction

I noticed that although the students engaged in discussion from the beginning of the activities, discussion in the polarized collective zone was different from the discussion as collaborative contributors. I believe that the design of the argumentation activities, along with the teacher's support for students' active participation, sufficiently supported the students in shifting their role from passive recipients of information to active participants in discussion. This interpretation is supported by the students' active presentation of their ideas in the polarized collective zone. I think the discussion in the polarized collective zone could be interpreted as the beginning of the dynamic negotiation of the students' positional framings. The students proposed diverse ideas from the beginning and did not remain passive recipients of information from authoritative sources. The multiple voices raised in this zone could be understood as possessing the potential to change the existing pattern of interaction; however, the representative feature of the zone was the students' dependence on Hyun. The active sharing of students' own ideas is considered one of the main aspects of students positioning themselves as active participants in knowledge construction (Rosenberg *et al.*, 2006).

However, this discussion lacked critical evaluation of the proposed ideas, which could hardly be interpreted as an exchange between collaborative contributors compared to the later interactions in the collective zone. The students' attention to Hyun's agreement with their ideas indicated their persistent reliance on Hyun, whom they perceived as holding higher epistemic authority. The moments when the students either gave up their ideas or insisted on their ideas without revising them despite critique were easily identified. The students lacked acknowledgement of one another, except Hyun, as the possible contributor for the

development of their ideas. This feature distinguished the polarized collective zone from the collective zone, in which various students take a chance on proposing ideas and discussing them. Although the argumentation activity that was implemented provided the context that encouraged the students to engage in discussion and elicited their diverse ideas, the students' positioning as collaborative contributors emerged after they negotiated their positional framings in interactions which was facilitated by Min's agency.

4.6.2 Contribution of Min's agency to the shift in students' framing

I noticed that Min's initial shift in positional framing and her agency led to subsequent discordance with other students' framings, which was followed by negotiation and shifts in the other students' framings. Specifically, Min's agency was shown in her continuous attempts to join in the other students' interactions and establish common ground regarding the concept of cellular respiration through discussion with the other participants. Min encountered Hyun's position as an authoritative source and Jeong's exclusion of the other students from her interactions with Hyun. This situation prompted Min to seek another participant in the discussion, thereby initiating changes in the existing pattern of interaction. This shift subsequently led to changes in the existing pattern of interaction, initiating a separate zone of interaction from Hyun in which Hyun was able to transfer her framing of the group and facilitate Yeon to align her positional framing with Hyun's framing. I suggest that such a change in the positional framing in this separate zone worked as a stepping stone for the students to engage in a collective zone of interaction as collaborative contributors.

I considered that Min's active role in initiating negotiations in the students' positional framings showed that students who held lower epistemic authority due to their activation of relatively fewer canonical ideas could nonetheless play a major role in facilitating collaborative discussion in argumentation activities. The number of canonical ideas possessed by the students cannot be described as equal, which represents the situation in many other science classrooms. However, I inferred that Min's repeated attempts to be acknowledged as a contributor promoted the students' alignment of their framings as collaborative contributors, reflecting her positional framing as a contributor. Hyun's attempts to make sense of the phenomena through discussion led to more detailed reasoning being delineated than the line of reasoning using scientific terms. Although Min's attempt was not transferred at first, her repeated attempts led the other students to shift their framing as well, activating various kinds of ideas that became more sophisticated despite rejection by a student with higher epistemic authority.

The dynamic changes in the students' positional framings initiated by Min's shift in her personal framing could be interpreted as consistent with the discussion in the literature of students' agentic practices to transform participation in activities in science classroom (Varelas, Tucker-Raymond, *et al.*, 2015). In the polarized collective zone of interaction, Min's attempts to join the interaction between the other students were initially not successful, because they were constrained by the other students' persistence in their framings. Confronting this discordance between her and other students' framings, Min tried to form a separate zone of interaction in which her framing could be shared with another student and eventually align with the other students after her persistent attempts. In other words, in an attempt to share her positional framing as a contributor, Min was able to

engage in a different pattern of interaction that facilitated the sharing of her framing. In addition to Min's major role in providing the contextual cues that facilitated shifts in the students' framings (Hutchison & Hammer, 2010; Louca *et al.*, 2004; Rosenberg *et al.*, 2006), her agency in the shift in her positional framing as a collaborative contributor and her persistent attempts to transfer her framing to others seemed to be the main driving forces that facilitated the group's negotiation of their positional framings and, eventually, productive discussion in the collective zone. This case indicates that a student's repeated attempts to initiate negotiations of their roles in discussion could be a significant feature of their positioning as collaborative contributors in argumentation.

4.6.3 Framing as collaborative contributors in argumentation activity

Comparison of the students' discourses in the polarized collective zone and those in the collective zone after the negotiation of their positional framings showed that being collaborative contributors was more than just being active participants in discussion. Being collaborative contributors in an argumentation activity implies that students share a common understanding of the epistemic goal of the argumentation activity in which they are engaged, allowing a space for other participants to become involved in validating the reasoning behind the knowledge claim. This involvement is more than being a sole active participant in the knowledge-building activity or just assuming the existence of a listener on the other side.

Specifically, clear differences in the students' attitudes toward each other as listeners in each zone were noticeable. In contrast to the polarized collective

zone, in which the students were indifferent to each other's ideas, in the collective zone, the students paid attention to each other's words, considering suggested ideas as potential constituents of the argument that they were developing. Furthermore, this framing differed from Hyun's rejection of the other students' ideas in the polarized collective zone, in which Hyun's responses seemed to indicate that she was the assessor of the validity of the other students' ideas. This difference underlines that engaging in a dialogical argumentation activity implies that the participants take up the proposed ideas, including ideas about which they are skeptical at first, and then critically evaluate their validity. This is in line with the previous literature that has highlighted the construction of both safe and hostile environments in which students could propose their ideas in the public domain (Ball, 1993; Engle, 2012). This study adds to the literature by showing that collaborative contributors in an argumentation activity are not just sources who actively propose ideas but also listeners who attend to the ideas suggested by other students and acknowledge their potential, even if they do not initially agree with that student's viewpoint.

4.7 Chapter Conclusion

This study explored how students transferred and negotiated their positional framings of themselves and one another through interactions as they framed their positions as collaborative contributors. In this section, I address several implications of this study.

First, based on previous studies that investigated the contexts that could facilitate students' engagement in productive practices in science classrooms (e.g., Berland & Reiser, 2011; Engle & Conant, 2002; Hutchison & Hammer, 2010;

Rosenberg *et al.*, 2006), the present study focused more concretely on how students negotiated their positional framings as they acknowledged one another's active roles in discussion in an argumentation activity. The contexts that triggered the students' active participation in discussion facilitated their proposal of ideas and their engagement in discussion, and further negotiation of the positional framings enabled the students to position themselves as collaborative contributors. The findings showed that the students' positional framings shifted in relation to each other and shifted differently depending on whom they interacted with. The students' discussions showed a lasting influence on students' perceptions of the higher epistemic authority of the student possessing more knowledge of scientific concepts, which had been formed in a didactic classroom. These perceptions were reflected in this student's framing of the different positions of the other participants. The student with a framing of others as collaborative contributors, Min, was able to transfer her framing to another student, Yeon, in the separate zone of interaction from the student who was framed as an authoritative source. I think that the formation of the separate zone supported this change, because the separate zone provided Yeon with another condition in which to compare participants' roles in the interaction that was different from the one in a zone with an authoritative source. The specific positions that students frame could differ in other classroom contexts, but the present study indicates the importance of considering the relative aspect in the exploration of the shifts in students' positions during knowledge-developing discussions in science classrooms.

Second, I noticed that Min's shift in her positional framing and her agency in the sense of transferring the shifted framing to the other group members and facilitating the negotiation of framing played significant roles in the students'

positioning as collaborative contributors. I think that Min's shift was facilitated, at least to some degree, by the argumentation activities that aimed to encourage the students to propose knowledge claims supported by valid reasoning. In addition, Min's motivation to build a common understanding of the given phenomena facilitated the students in sharing this epistemic understanding. Based on the shared positional framing, along with the established common understanding, the students were able to engage in communal evaluation of the validity of the reasoning that supported the proposed arguments. This change indicates the significance of Min's role in acknowledging herself and the other participants as collaborative contributors, as she transferred this framing in interactions with other students and helped them consider their everyday experiences as available for use in the development of reasoning. Many studies have explored how students' diverse ideas are acknowledged by teachers encouraging students to engage in productive discussions (e.g., Hammer *et al.*, 2012; Stroupe, 2014). This study suggests that it is important for students, not just teachers, to share framings of one another as collaborative contributors to form a community of epistemic agents in the science classroom. In addition, this study shows that such acknowledgment among students can be achieved through the negotiation of their positional framings facilitated by their agency. I hope that future studies will explore the dynamic shifts in positional framings during discussions and the student agency that supports this process and how we can facilitate students' positioning of themselves as contributors to such discussion.

Third, the findings show that being collaborative contributors is more than just engaging in discussion in that being collaborative contributors allowed other participants to suggest ideas that would be acknowledged as resources and to

become involved in the modification of the proposed ideas. The alignment as collaborative contributors emerged, as the students encountered discordance multiple times and dynamically shifted their framings. The dynamic shifts in students' framings and interaction patterns may have been a necessary step since the students encountered argumentation activities in which they all could share their ideas. They were encouraged to raise their voices in dialogical argumentation activities, not randomly but harmoniously, and to value one another as capable of contributing to development of their ideas. This is an important aspect for the joint development of knowledge claims in science classrooms. However, these dialogical features are unfamiliar to students who are familiar with didactic instruction in the science classroom. Future studies could investigate the features of interactions that facilitate students' alignment of their positional framing of themselves and one another as collaborative contributors at the moment that they encounter discord in their framings. Additionally, I recommend that further studies continue to develop instructional support to facilitate and stabilize such positioning and collaborative discussion.

Fourth, investigating shifts in positional framings in different types of argumentation activities, such as discussions with teacher or the entire class, would help us deepen our understanding of students' epistemic practices. In the case I explored, the discussion was among a group of four students, and the teacher hardly engaged in the students' discussion in the group, except when the students asked her to answer questions. However, a different power structure could have afforded or constrained transference of the students' framings if the teacher had frequently engaged in the discussion. There are various other forms of argumentation in science classrooms that afford and constrain students' discourses

differently. Exploring students' positional framings in various contexts would help us provide instructional support to facilitate their participation in argumentation as a community of epistemic agents.

Finally, this study suggests that science educators need to consider student agency that facilitates students' negotiation of framing and how students afford one another to engage in discussion in a context that facilitates active participation. I noticed that shifts in and alignments of the participants' positional framings proceeded through discursive interactions, affording and constraining the subsequent changes. Shared positional framing as collaborative contributors in the case that I explored emerged during the students' complex exchanges of their framings as meta-messages in their interactions. Min's agency played a key role in these led these changes and interactions. To support such emergent achievement of collaborative positions in dialogical argumentation, I suggest that science educators provide a classroom environment in which students can share their framings and notice the differences in their framings. It is also necessary for teachers to support students in perceiving one another as collaborative contributors and in exercising their agency by encouraging others to engage in critical evaluation and improve the sophistication of their reasoning. Furthermore, I suggest that further studies can develop and explore science educators' interventions in supporting student agency, which would support for students to form collaborative learning communities rather than work as individual learners and to form learning communities in argumentation activities in science classrooms.

Chapter 5. A Marginalized Student's Attempt to Position Himself as a Collaborative Contributor in Small-Group Argumentation in a Science Classroom

5.1 Overview

This study focused on a student who had been marginalized in group's discussion and aimed to explore his agency from his attempts to be accepted as a collaborative contributor in small-group argumentation activities in a science classroom. A teacher and 29 students participated in small-group argumentation activities on the subject of photosynthesis. I focused on how the marginalized student, whose epistemic authority was not being acknowledged by other students, continuously attempted to engage in discussion with the other students. The students' discussions in the classes and our interviews with the focus group were recorded. The records were transcribed for an analysis of the discursive interactions that demonstrated the marginalized student's attempts to position himself as an accepted member in the group discussion. Then I analyzed how the group members' framing of the activity was negotiated in the subsequent discussion. The student's agentic discursive moves were categorized as "presentation of reasoning," "presentation of epistemological framing," or "presentation of reflection on the previous epistemic practices." The students' negotiation of group activities in the subsequent discursive interactions varied with their respective positional framings of the marginalized student and power relations. I describe how the argumentation activity as the context of science classroom activity influenced these interactions. This study can further our understanding of how the students negotiate their positional framings and shape their understanding of argumentation activities in science classrooms.

5.2 Chapter Introduction

In science education, argumentation activity has been highlighted as providing a classroom context that affords students to position themselves in the center of the development of knowledge (Ford, 2012; Kolstø & Ratcliffe, 2007). Students have been depicted as being in the center of the argumentation activity through their active participation in discussion that involves justifying and critically evaluating a knowledge claim (Nussbaum, 2008; Sampson & Clark, 2009; Stroupe, 2014). In particular, Sampson and Clark (2009) highlighted that it is important for students to listen to one another's ideas and evaluate alternative knowledge claims together rather than simply interacting with other participants. These studies showed that it is important for students to acknowledge one another as collaborative contributors to the development of knowledge as well as work as active participants themselves.

However, I noticed that even in the argumentation activities that were designed for students' active participation, it is common for students not to engage in discussion with other participants in argumentation activities in science classrooms. I also noticed that one of the main reasons for this could be because argumentation activity provided a context in which students' existing social relationships, which used to be hidden in the teacher-centered classroom, are brought to the forefront and negotiated. Students' existing social relationships influence their initial positioning, and students have conflicts and negotiate their positions to acknowledge one another as collaborative contributors. This study aimed to address this issue, more specifically, how students negotiate their participation patterns in subsequent discussions. Furthermore, to explore how these conflicts and negotiations are continued, I focused on student agency in the attempt

to be accepted as collaborative contributors in a group discussion. To address this issue, I approached student agency based on studies that have discussed agency in relation to how students transform the structures of learning activities in which they are positioned as active participants (Barton & Tan, 2010; Basu *et al.*, 2009; Stroupe *et al.*, 2018; Tan & Barton, 2007).

Based on these previous studies, I aimed to further the understanding of students' practices and agency in argumentation activity in the following aspects. First, I focused on a student who was marginalized in discursive interactions with the other students, and explored his discursive practices that reflected his agency in his attempts to be accepted by the other students as a collaborative contributor. Previous studies on marginalized students' agency have mostly focused on students who were marginalized largely because of their different cultural backgrounds or gender. In the science classrooms, I noticed that there were many students whose epistemic authority was undermined and who did not engage in discussion with other students, even though they did not have minority cultural backgrounds or gender identities in the science classroom. This study focused on a student with these features who was marginalized in peer group and exercised his agency by attempting to position himself as an accepted member of his group and by facilitating negotiation of the participation pattern in subsequent discussions.

Second, this study explored student agency in argumentation activities in science classrooms, which highlights the reflection of the scientific community's epistemic practices. Previous studies on student agency have mostly explored learning activities, such as a science project in a local community club, which are open to transformation into various structures through the adaptation of students' diverse cultural resources (e.g., Barton & Tan, 2010). However, argumentation

activity in science classrooms highlights the enculturation of the social and epistemic practices of the scientific community as students actively participate in the development of communal knowledge. I think exploring student agency in this context is important for understanding and supporting students' positioning in the center of learning activity while reflecting the scientific community's epistemic practices. Bryan Brown's study (2004) also addressed this issue and described how multicultural students can maintain agency in the sense of incorporating scientific discourse into their everyday discourse. I think that the current study contributes to showing how a marginalized student can incorporate dialogical features of scientific argumentation into his discursive moves in an attempt to be recognized by other group members.

Third, this study investigated how students' participation patterns changed through their negotiation of framing during discussions subsequent to a marginalized student's agentic discursive moves. In many studies on student agency, teachers who take up the cultural resources of marginalized students have played important roles in transforming classroom activities and positioning marginalized students as accepted members of the classroom. This study investigated the context of small-group argumentation activity in which the teacher could not consistently support students' participation and in which students were responsible for acknowledging one another's epistemic authority in collaborative work. By exploring the conflicts and negotiations in this learning activity, I aimed to understand how students formed a collaborative learning community in an argumentation activity in the science classroom. The specific research questions were as follows:

(1) What were the discursive moves that reflected student agency in attempting to become a collaborative contributor in small-group argumentation activities?

(2) How did the students negotiate their framing of small-group argumentation activities in the interactions following the discursive moves?

(3) How did argumentation activities in the science classroom context affect the students' negotiation of framing?

5.3 Framework for Analysis

This study aimed to explore a student's attempts to be accepted as a collaborative contributor in a small-group argumentation activity in a science classroom. I looked for a group that clearly showed uneven power relations between students, and I focused on a small group with a marginalized student whose epistemic authority was not acknowledged by the other students in the group. The reason for this focus on the marginalized student is because the discursive interactions around the marginalized student can more clearly depict shifts and transferences of students' framings during their discussion and changes in the acknowledgement of epistemic authority of the student who exercised agency. The difference of the focus on the marginalized student in this study from the previous studies is that this study assumed that "marginalization" among students can be attributed to the deviation of a student from the majority of the students' understanding of an activity and their usual practices in that activity. The previous studies on transformative agency have focused on students who were part of socially marginalized groups and whose cultural resources were not recognized (Shanahan, 2009). For example, Tan and Barton (2007) noted that students who have been alienated due to their cultural backgrounds and appearance are typically

shy and passive in science classrooms and that students' sociocultural backgrounds influence their identities and participation patterns. Even if students' cultural background and appearance are not associated with a minority group, those who are perceived to deviate from the activity in science classrooms are often not accepted in interactions with other students. These students' epistemic authority, in the sense of being capable of participating in a discussion and contributing to knowledge development, can easily be unrecognized. This situation can be easily seen in the Korean classroom context. However, there has been little discussion of such students or how students acknowledge one another as collaborating participants. In this study, I focused on a student who was marginalized in his attempts to participate in a discussion with other students. I explored this student's agency, more specifically, how he attempted to be accepted by other students in the group discussion, and how the structure of the argumentation activity was negotiated in the following discussion. For this research problem, based on the theoretical framework of this dissertation, I analyzed the students' discursive interaction as follows.

5.3.1 Identifying the discursive practices of agency based on Emirbayer and Mische's (1998) perspective on agency

In this study, considering the dialogical features of argumentation activities, I investigated a marginalized student's agency in terms of the discursive practices in an attempt to position himself as an accepted member of a discussion with other students. To identify the student's discursive moves, I followed Emirbayer and Mische's (1998) perspective on agency, which they described as a temporally constructed engagement by actors in different structural environments

through the interplay of habit, imagination, and judgment (p. 970). Based on this definition, Emirbayer and Mische delineated the constitutive elements of agency as iteration, projectivity, and practical evaluation. 'Iteration' is explained as "the selective reactivation by actors of past patterns of thought and action" (p. 971). It can be understood as the activation of the resources identified by participants as relevant to the current activity in which they are participating. The second element is 'projectivity', which is described as "the imaginative generation . . . of possible future trajectories of action, in which received structures of thought and action may be creatively reconfigured" (p. 971). The last element is 'practical evaluation,' which is explained as "to make practical and normative judgments among possible alternative trajectories of action, in response to the emerging demands, dilemmas, and ambiguities of presently evolving situations" (p. 971). This operationalized approach allows for the identifying of an agent's ideas about transforming or maintaining an existing activity structure, which are shared in discussion with others. In science education, Varelas, Tucker-Raymond, *et al.* (2015) adopted this approach to explore the classroom context with an integrated science-literacy program and described how a marginalized student's various discursive moves in different positions were accepted or not accepted by the other participants. They discussed the marginalized student's agency as engaging in the co-construction of an activity structure with other students. However, on the occasions when other students accepted the marginalized student's ideas, a teacher's scaffolding played a critical role in this acceptance. In the current study, based on Emirbayer and Mische's perspective on agency, I examined a marginalized student's agentic discursive moves to contribute to shaping group activity in a discussion with other group members with little teacher intervention.

5.3.2 Capturing the structure of activity through students' epistemological and positional framing

To explore how the students negotiated the structure of argumentation activities in their discussion, I investigated how each student perceived the activity structure and how this perception was shared and negotiated in discursive interaction. To address these features, I explored the structure of the activity structure from a framing perspective. Because this study focuses on how a marginalized student attempts to obtain acknowledgment of his epistemic authority to participate in argumentation activity, I specifically focus on epistemological framing and positional framing. To infer the students' epistemological framing, I followed Berland and Hammer's (2012) description of epistemological framing in argumentation activity as an individual's expectations with regard to how knowledge is developed in the activity. To infer the students' positional framing, I followed the description of how individuals entitle or expect themselves and each other to participate in their interactions (Greeno, 2009; van de Sande & Greeno, 2012). I especially focused on the students' framing on the marginalized student's position in argumentation activity. In the discussion following the discursive moves of the marginalized student, I explored how framing was negotiated in student discussion after the agentic discursive moves and how the other students' framing afforded or constrained the acceptance of the marginalized student as a collaborative contributor in the group discussion.

5.3.3 Exploring "why" the framings were negotiated in a certain way with a focus on the students' power relations

To understand why a marginalized student's agentic discursive moves were accepted or not accepted by other students, I borrow Jennifer Gore's idea (1995) that a teacher's epistemic authority is maintained through daily interactions in the classroom. Based on Mischel Foucault's perspective (1977, 1980), Gore delineated teachers' discursive strategies that help to maintain their epistemic authority. Since the students had experienced power relations between themselves and teachers in classrooms for years, I expected that, when these discursive strategies were demonstrated by a participant during interactions with other group members, the other group members would recognize the participant's intention to position himself or herself with higher epistemic authority than before.

While the previous studies on power have questioned what power is and from where it is derived, Foucault (1980) questioned how power is exercised and the results of the exercise of power (Lee, 2009, p. 293). He further argued that in modern society, power is not possessed by a specific institution or person, and it is not exercised through punishment. Instead, he explained that power is everywhere within the network of relations, and, especially with regard to knowledge and discipline, power is exercised in discourse in a specific field. Specifically, he described how in a certain discipline, specific practices are conducted to produce specific products (Foucault, 1977). These "valid" practices are recognized and normalized, and those that do not fit into such disciplinary practices are excluded, which is how power is exercised in combination with knowledge (Foucault, 1977). Foucault (1971) explained that people set the standards for normalization and exclusion through discourse, and he categorized exclusion as external and internal

exclusion. Internal exclusion, delineating a detailed standard of normalization and exclusion, can be easily identified in academic discourse (Lee, 2009). A typical example of internal exclusion is ‘commentary,’ which refers to a mode of discourse in which an author clarifies the intended meaning of the primary text because it can be interpreted in several ways. The standard of normalization and exclusion, accumulated and organized as knowledge, is regarded as valid and reasonable, and Foucault asserted that this regard is power itself.

In school, particular knowledge and practices are selectively privileged. In this sense, power does not simply oppress students, but it has a productive aspect that facilitates students’ participation in disciplinary work and in the construction of disciplinary knowledge (Danielsson, Berge, & Lidar, 2018; Donnelly, McGarr, & O’Reilly, 2014). However, because school is a place where a particular epistemic practice is privileged, school is also the locus from which power emerges and differences in epistemic authority are formed.

Based on Foucault’s argument, Gore (1995) described the discursive strategies of teachers to maintain their status as epistemic authorities, which have been empirically captured in later studies (Danielsson *et al.*, 2018; Donnelly *et al.*, 2014; Ö hman, 2010). For example, Danielsson *et al.* (2018) explored the context of technology classrooms in which students designed architectural models. The researchers analyzed the relationship between knowledge and power based on the discourse wherein teacher monitored and led the students’ discussion to design the model. Donnelly *et al.* (2014) identified a teacher monitoring and guiding students’ inquiry activity with regard to acid titration. The researchers found that although it was the students who constructed knowledge, the teacher’s epistemic authority was still maintained with these discursive strategies.

Student participation in the negotiation of the structure of an activity indicates the use of discursive strategies that have been used to maintain the teacher's epistemic authority in the classroom. In this study, I explored the negotiation of the structure of argumentation activities in relation to the positioning of a marginalized student based on Gore's (1995) discussion of discursive strategies that form differences in epistemic authority in the classroom. Gore's discussion allows me to infer how other students would interpret the positioning of the marginalized student based on his epistemic practices. Furthermore, from empirical analysis studies based on Gore's (1995) perspective, I was able to infer how students used the context of argumentation in science classrooms to justify or exclude certain epistemic practices. Additionally, this perspective allowed me to infer the students' positioning, how the marginalized student's positioning shifted or was maintained in the students' discursive interaction, and how the students negotiated the epistemological framing of the argumentation activities with regard to their positioning.

5.4 Research Context and Methods

I chose the case study method (Merriam, 1998) to gain an in-depth understanding of how framing of the small group's argumentation activity was negotiated with the marginalized student attempted to be accepted as a collaborative contributor in their group discussion. I purposefully focused on the small group with a student who was marginalized among the students' social interactions. The specific research context and methods are as follows.

5.4.1 Research participants

One teacher (Ms. C) and 29 students in a seventh-grade science classroom in a private school participated in the study. The researchers introduced the purpose and details of the study to Ms. C and the students. They were told that they could choose not to participate in the study, and there would be no negative repercussions for doing so. After the introduction to their research participation, they consented to take part in the study by signing the consent form, which was approved by the Institutional Review Board in Seoul National University (IRB No. 1604/003-011).

The school's tuition is high, and the students' families are upper-middle class. The school has facilities and systems to actively support students in various activities, and the school provides relatively active support for students, including students with disabilities. The participating teacher has worked at the school for a long time. She has a master's degree in science education, and her dissertation was about scientific argumentation, which indicates her strong interest in and understanding of argumentation activities in the science classroom.

The students formed seven small groups, with four or five students in each group. The groups were organized on the basis of gender and the relationships between the students to facilitate communication in each group. Interviews were conducted after each class to obtain an in-depth understanding of how the students thought of their social interactions and cognitive practices in the group activity.

5.4.2 Research context

The argumentation activities in this study were focused on concepts related to plants and photosynthesis, which was also implemented in the science

Table 6. Topics of the argumentation activities in each lesson

Lesson #	Topic of the activity
1	• Introduction to argumentation • Establishing rules for the small-group activity
2	• Function of roots
3	• Osmosis (carrot's absorption of water)
4	• Transportation of water through xylem
5	• Observation of leaf tissue • Transpiration
6	• Reactants of photosynthesis
7	• Light intensity and photosynthesis • Cellular respiration of beans
8	• Girdling

classroom in the previous case study in Chapter 4. However, because this school operated on a block schedule, which means one class covers two periods (90 minutes), Ms. C adjusted the number of argumentation activities to be addressed in one class to ensure that the time needed for group discussion was sufficient but that the activities were not disorganized (Table 6, Appendix 1).

5.4.3 Selection of the focus group

To explore a marginalized student's transformative agency in the students' discursive interactions, I chose a group whose discursive interaction clearly featured a student whose epistemic authority was not accepted by the other group members but who continuously attempted to engage in discussion, thus having conflicts with other students in this group. The members of the group that I chose were June, Yoon, Jane, and Lin; June was the marginalized student.

There was much evidence that this group met the criteria of this study. After the students were introduced to argumentation and the structure of arguments,

the students in the focus group drew up their group rules, as shown in Figure 4. The first and the second rules indicated that, to enable productive discussion in argumentation activities, the students understood they needed to actively suggest ideas and listen to each other's suggestions. These rules were also commonly used in other groups. However, the third rule was distinctive from those of the other groups; therefore, in the interview, I asked the students why they had come up with this rule. Lin told me, "It's made for him (June), but he constantly breaks it." June rebutted by saying, "Why is that made for me?" He told me, "They say that the 'no jokes or pranks' rule is made for me, but in fact, I want to say that this rule is also for them." Jane said, "It doesn't matter because the rules are to be kept by all of us," demonstrating her support for maintaining the third rule. This interview implied that conflict had occurred between June and the other students because the other students thought June's jokes and pranks were negative; however, June did not accept the other students' views and continued his behaviors.

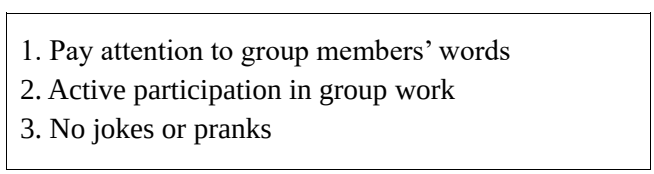


Figure 4. Group activity rules established in the focus group

June was also frequently criticized by the other students in the classroom. The students explicitly showed their negative perceptions of June, saying, "When I first saw him in our group, [I thought that,] uh, we are screwed," "You are like . . . an attention seeker by nature." Despite such insults, June continued to joke with other students and ask for their perceptions of him, which only escalated their conflicts. Such conflicts were more explicitly delineated when I asked the students

to share their understanding of one another's practices in group work. June said, "That's the way I play with my friends . . . and if I think that I've gone too far, I stop myself. . . . It's annoying that they attempt to teach me and ignore me." However, the other students said, "I think June plays too much," ". . . I was angry because he does not admit that he did wrong," and "I think June's ignoring us because he does not listen to us saying stop talking."

In line with this conflict, June was rarely acknowledged as a contributor in the discussion of the development of the group's arguments. However, he continuously attempted to engage in the discussion, and the other students occasionally accepted his ideas (Table 7 in the Findings section). June continuously showed that he tried to engage in group discussion. For instance, in the interview after the fifth lesson, when I asked June why he did not share his idea with the other students, he said, "They did not ask me what I thought." Then, Yoon rebutted, "No, it's not like that. We were talking in turn, but he did not talk on his turn." Then, June said, "No, you always say 'I didn't ask you' when I try to say something." When I asked the students what their responses to the questions of the argumentation activities in the lessons were, June actively presented his own idea. He also actively participated in the whole-class discussion and shared his ideas. These practices show his intention to participate in discussion. However, in the group discussion, his ideas were not recognized as useful and his participation was constrained by the other group members.

The students were in the seventh grade, and in the Korean education system, seventh graders do not receive achievement assessments. Therefore, they seemingly did not recognize each other's differences in achievement, and June's marginalization was not attributed to his level of academic achievement. Rather, I

found that the reason for marginalization was June's interplay with other students during the class, during breaks, and in the interviews. The other students occasionally responded to the pranks; however, if the pranks continued, they asked him to stop. Nevertheless, June continued the pranks, which often upset the other students. June asked the other students why they considered his behavior wrong. He sometimes stood up to the other students, asking why only he was criticized among all the other students involved in pranks and jokes. Thus, June tried to attract the other students' attention by behaviors that were irrelevant, and the other students disliked him because of these behaviors and utterances.

However, after all the argumentation activities, in the interview after the eighth lesson, the students' responses showed changes in their positioning. When I asked ". . . Is there any change in the relationships in your group?," Jane said, "June's words are not all strange." In addition, Lin said, "I think I learned how to pay attention to June's words more and more as the class went on." They agreed that June had "actively presented his ideas" in discussion. These responses indicated changes in their perceptions of June. Thus, in this small group, it was clear that the students' positioning of June, who had been marginalized based on the discussion of argumentation, had changed. Therefore, I chose this group as the focus group to explore student agency in June's discursive practices and the negotiation of framing in the following discussions with the group members.

5.4.4 Data collection and analysis

Data collection

As in the previous case study in Chapter 4, each group was recorded on audio and video; the researchers also recorded observations in field notes. The

groups that showed active interactions were selected, and semistructured interviews were conducted with them after each lesson. The interview questions were focused on the students' reflections on their practices, their cognitive understanding of the main content of the activity, and their social relationships during their discussions in class. If the students did not reach a consensus during their discussion in class, additional time was provided to continue the discussion in the interview.

Interviews were also conducted with Ms. C after each lesson. The interview questions were focused on her understanding of the goals of the argumentation activities, her expectations of the students' practices, the students' unexpected practices she encountered in the lesson, the students' ideas that she noticed in the lesson, and her support for students' participation in the activities. The interviews with Ms. C were used to ascertain how the teacher understood and implemented the argumentation activities in her class and her intention in responding to the students' ideas when she intervened in the group discussions. The interviews were also recorded. The recordings of the students' and teacher's discourses both in class and in the interviews, were transcribed to obtain more detailed analysis. In the transcriptions, not only verbal utterances but also characteristic tones, facial expressions, and gestures were recorded for data analysis.

Data analysis

The first research question of this study is about identifying the marginalized student's agentic discursive moves in his attempts to position himself as a participant in small-group argumentation activities. This study was based on a framing perspective, in which students' discursive practices are dependent on their

framing of the situation, and students' framing can shift according to the contextual features on which they focus. First, to identify the contexts of student discourse in group discussion, I largely divided the discourses into discourses that are relevant to the topic of the argumentation activity and discourses situated outside the topic. Then, I subdivided the discourses relevant to the topic based on the concepts used in the students' reasoning. Then, for the analysis, I focused on the contexts that included June's utterances.

I repeatedly observed the recordings and the transcriptions, focusing mainly on the students' discourse, tone of voice, facial expressions and gestures based on the constitutive elements of agency suggested by Emirbayer and Mische (1998), and I attempted to delineate June's agentic discursive moves. I engaged in many discussions with other researchers and conducted iterative revisions based on the data to identify the discursive moves and to clearly distinguish each move. The discursive move that I drew from the 'iteration' aspect was June "presenting reasoning based on his cognitive resources." This move is delineated based on the notion of both the framing perspective and the interplay of structure and agency, which defines participants as reactivating the cognitive resources associated with their framing of the activity that they bring from other situations from their past. The discursive move that I drew from the 'projective' aspect was June "presenting his epistemological framing" of the given activity. Framing is a participant's expectation of how an activity will be performed, which provides goals and trajectories for the activity, and this feature corresponds to Emirbayer and Mische's explanation of the projective aspect (1998). Last, the discursive move from the 'practical evaluation' aspect was June "presenting his reflection on the epistemic practices." Specifically, this move was a presentation of an evaluation of the

validity of previously shared resources or epistemological framing based on June's own epistemological framing. The specifics of each discursive move are explained in the findings section.

I identified each discursive move based on the more explicitly delineated element of agency from June's utterances. For example, in the discursive move 'practical evaluation,' June's epistemological framing could be implicitly transferred to the other students because his framing was used as a standard to evaluate other students' epistemic practices. Thus, the discourse on the 'practical evaluation' aspect reflected the 'projective' aspect of agency. However, the three elements of agency were not delineated as separate elements but as interrelated elements, as in Emirbayer and Mische's work (1998). Furthermore, this study focused on June's agency, which could be delineated based on his discourse during interaction with other students. Therefore, I identified each discursive move, mainly focusing on the element of agency to which the explicit message of June's utterances corresponded.

The students' epistemological framing and positional framing were inferred from their discourse in class and their responses in the interviews. Since the main intention in designing the argumentation activities was to facilitate dialogical argumentation (Ford, 2012) in student discussion, I inferred the students' epistemological framing by asking how their framing differed from dialogical argumentation. The positional framing was inferred with a focus on how the students framed June's position in the discussions following June's agentic discursive moves. Then, I explored how the framing afforded or constrained the space for group members' participation in the discussion.

The second research question required the empirical exploration of how the students negotiated their framing of small-group argumentation activities in their interactions following the marginalized student's discursive moves. To answer the second research question, I identified the types of student interactions that followed each of June's discursive moves that reflected her agency. The students' interactions were inductively categorized based on the question of whether and how they accepted or did not accept June's cognitive ideas in their discussion in each context. The initial codes were ignoring, criticizing, objection, reinterpretation, or acceptance. 'Ignoring' meant not responding to June's utterances or simply agreeing not to discuss June's ideas any further, followed by the other students' discussion and exclusion of June from their interaction. 'Criticism' meant the other students' immediate rebuttal of June's utterances, dismissing June's ideas and strongly revealing their non-acknowledgment of June as a collaborative contributor. For example, when June complimented Yoon's example, Yoon responded emotionally, saying, "Are you judging me now?" I categorized the discourse in which the students showed a strongly negative perception of June's position as an evaluator of the other students' ideas as 'criticizing.' 'Objection' meant the other students responded to June's utterances in the same discursive move as June's and did not pursue June's ideas. For example, when June asked, "What did you write?," asking the other students to share their ideas, the other students rejected the question by saying, "Just write your thoughts first, and then let's discuss later," or "Why would I tell you that?" 'Reinterpretation' meant revising June's interpretation of the previous discussion. A representative discourse of 'reinterpretation' is when June argued that his idea should be presented as the group's consensual idea in the whole-class discussion because Yoon said he agreed

with June's idea. Other students rejected this suggestion, and Yoon reinterpreted his agreement by saying that he was not agreeing with June's idea but suggesting his own idea, which happened to be the same as June's. 'Acceptance' referred to the acceptance of June's idea as a valid idea to be addressed in discussion. When the students accepted June's idea after conflicts with other responses, the context was coded as 'acceptance.'

Then, these codes were constantly compared with the data and modified to more clearly distinguish the differences in the students' framings and negotiations for each code. The final codes were established as follows: (a) restriction: restricting opportunities for June to delineate his cognitive resources or framing in the discussion; (b) rebuttal: rebutting June's cognitive resources with other cognitive resources or rebutting June's epistemological framing with other epistemological framing; and (c) acknowledgment: acknowledging June's ideas as potential contributions to the discussion.

Based on these coding results, I interpreted that June's resources or framings were recognized by the other students when the resources or framings were addressed in the discussions following June's agentic discursive moves. I explored how June's positioning and the students' epistemological framings were negotiated in these discursive interactions. Specifically, I explored the student discourse in terms of how the students delineated their framings, why they shifted their framings, how they transferred their positioning in response to one another, and what caused the shifts in their positioning.

The third research question addressed how the argumentation activities in a science classroom context affected the students' framing negotiation. To answer this question, I revisited the findings of the first and second research questions,

exploring what features of scientific argumentation were used by June to justify his ideas as valid contributions to the discussion and how the other students justified their responses to June's ideas. I also analyzed in which aspect of the argumentation activities or interviews with the researchers the students encountered and adopted these features of scientific argumentation in their practices. Then, I explored how the students' perceptions of scientific argumentation were modified in their discussion.

The data selection and analysis were conducted based on the participants' practices in class, the interviews, and the field notes. In particular, I analyzed the students' epistemic practices, their epistemological framing, and June's discursive moves, using the students' practices in class and the interview transcripts as the main data sources. Other data were used to support and modify the results of the analysis. The interviews with the teacher were used to understand her intended course of action and the intentions of her discourse in class. To increase the credibility of the data selection and analysis, I reached a consensus through discussion with other researchers. Based on the discussion with the researchers, I selected representative discourse excerpts that illustrate the features of each discursive move and the negotiations, which are presented in the following discussion.

5.5 Findings

This study aims to identify June's discursive moves in his attempts to be accepted as a contributor in small-group argumentation activities and the negotiation of the activity structure in the following discussion. June's discursive moves in each lesson and the types of discussion that followed are shown in Table 7.

June's discursive practices were identified as follows: (a) presenting reasoning based on his cognitive resources, (b) presenting his epistemological framing of the argumentation activity and pressing for the activation of resources that corresponded to his framing, and (c) presenting his reflection on the previous epistemic practices based on his epistemological framing. The types of the following discussion were categorized as follows: (a) restriction: constraining the opportunities for June to delineate his conceptual resources or framing in discussion, (b) rebuttal: rebutting June's conceptual resources with other conceptual resources or June's epistemological framing with other epistemological framing, and (c) acknowledgment: acknowledging June's ideas as potential contributions to the discussion.

Rather than appearing gradually, June's agentic discursive moves and the types of discussions that followed were interspersed in the group's discussions. In the next section, I describe each of June's discursive moves to transform the activity structure and the way in which the structure was negotiated in the following discussion.

5.5.1 Presenting reasoning based on cognitive resources

The most frequent agentic discursive move was presenting reasoning based on the activated conceptual resources. Based on the framing perspective and agency theory (Emirbayer & Mische, 1998; Sewell, 1992), the activated conceptual resources were interpreted as those that June recalled from another situation in the past, to which his framing of the current activity referred. This discursive move was also interpreted as showing June's intention to delineate that he was capable of

Table 7. Coding results of the discourses following June's agentic discursive moves in each lesson

Discursive moves by June	Types of discourse following June's discursive moves in the lesson #						
	2	3	4	5	6	7	8
Presenting reasoning based on his cognitive resources	RS (1)	RS (3)	RS (3) RB (1) AC (1)	RS (6) RB (1) AC (2)	RB (1)	RS (5)	AC (3)
Presenting his epistemological framing	RS (1)	-	-	RS (1)	RS (1)	RS (1) RB (4) AC (1)	AC (1) RB (2)
Presenting his reflection on the epistemic practices	RS (1)	-	RB (1)	RS (2) RB (1)	RS (2)	RB (2)	AC (2)

RS: restriction, RB: rebuttal, AC: acknowledgement
Type of the following discussion (number of discourse segments)

contributing to the development of valid reasoning. However, in many cases, the other students constrained June's participation by shifting to a framing that restricted everyone's participation in the discussion. Furthermore, even when accepting June's participation, the other students tried to lower June's epistemic authority in comparison to theirs by not accepting June as one of the contributors to the group. I explain the representative discourse excerpts in the following sections.

Restriction

In the excerpt in Table 8, when June tried to participate in the discussion, the other students tried to restrict his attempt by changing the discussion topic. This discourse occurred in the 'observation of the leaf tissue' activity in the fifth lesson. In this activity, a microscopic photograph of a cross-section of a leaf was presented

in a student worksheet. The leaf was placed vertically in the photograph; thus, there was no explicit sign showing the upper side of the leaf (the two sides were marked as Side A and Side B). The students were asked to observe and analyze the leaf structure in the photograph and to argue which side of the leaf was the upper side. The leaf tissue structure shown in the photograph was very different from the textbook model; thus, the students could not easily identify the parts of the leaf, which promoted student discussion.

In the discourse, the students other than June shared their ideas (lines 256-257), and June also attempted to share his argument (lines 258, 260). When Jane and Lin tried to analyze the structure of the leaf in the photograph (lines 261, 262), June also attempted to engage in the discussion (lines 263, 266). However, Jane responded to June simply by saying “yes” or “okay” (lines 259, 267), ignoring June’s utterances and restricting his further engagement in their discussion. Furthermore, in response to June’s utterance in line 263, the other students redirected their discussion to a private subject (lines 264-265, lines 268-269).

When they presented their opinions, the students, except for June, shared their arguments and reasoning to attempt to develop communal knowledge. This part of the discussion reflected their efforts to frame this activity as a ‘critical evaluation of individual ideas to develop the consensual argument.’ However, when June attempted to apply his cognitive resources to this discussion, the students stopped the discussion with a simple reply such as “yes” (line 259) or by redirecting the discussion to other topics. In other words, whenever June attempted to participate, the students’ epistemological framing shifted, indicating their intention not to engage with his resources in their discussion. In this manner, the students discontinued their discussion and switched their epistemological framing

Table 8. Discourse showing the restriction on June's presentation of reasoning 1 (Lesson 5, 'Observation of the leaf tissue' activity)

Line	Speaker	Discourse
256	Lin	I think it's [the upper side is] A, Side A.
257	Jane	I think it's Side A, too.
258	June	Guys, look at this part [indicating a specific part in the photograph]. So which part is the upper side here? (Only Jane is looking at June. Yoon and Lin are looking at their worksheets and evidence cards.)
259	Jane	Yes.
260	June	Oh, then I think it's Side A, too.
261	Lin	(Ignoring June's words) Then, it's palisade [parenchyma] here, and this is . . .
262	Jane	(Interrupting Lin's utterance) Umm, I think this part is palisade parenchyma, and that part is . . .
263	June	So, . . . I think so, too. Oh, and this part, below, is . . .
264	Yoon	(Interrupting June's utterance) Doesn't it look like the liver part that comes with a sundae?
265	Lin	Oh~
266	June	(Interrupting Lin's utterance) I kind of think that this part is the vessel, phloem here, and this part is, what was it called, the spongy [parenchyma].
267	Jane	(Staring and toying with her pen) Okay.
268	Lin	(Interrupting June's utterance, to Yoon) You know a lot of trivial things. (turning her head away from June and attaching evidence cards to her worksheet)

of argumentation activities when June presented his resources so that they could maintain their discussion without June.

The students other than June frequently switched their epistemological framing to limit June's participation in their discussion. In another example (Table 9), the students shared their individually built arguments, reflecting their framing of the group discussion as 'presenting individual arguments in order.' Under this framing, the students, including June, were able to present their ideas. However, the discussions after their presentation of individual ideas differed.

In the discourse, the students gave each individual ideas, including June, an opportunity to present an individual argument (lines 820, 821, 823). However, when June presented his idea, Lin was yawning and Yoon was talking to students in other groups, not paying attention to June's words (lines 825, 826). This indicates that, although the students allowed June to express his idea, it was limited to merely speaking, and their responses showed their intention not to consider his idea in their development of the group argument. The students' responses clearly contrasted with the discussion of the validity of reasoning (lines 831-842) immediately after presentation of their individual arguments. Therefore, the students framed the group discussion as 'presenting individual arguments in order' when it was June's turn to speak but then shifted the frame to 'critical evaluation of individual ideas to develop the consensual argument.' With this framing shift, the students marginalized June.

Furthermore, the students distinguished between June and themselves in their role as listeners. The students' criticisms of June's attitude as a listener (lines 841, 842) showed their monitoring of June's epistemic practices. June showed disregard for the other students' presentations of individual arguments (lines 836, 840), and this attitude was identical to those shown by the other students when June was presenting his argument. However, the students pointed out this attitude only when it was expressed by June (lines 841, 842). This indicates that the students separated the context of June's presentation from that of the other students' presentations, framing the activity in these contexts differently. In addition, the students monitored whether June's practices corresponded with their epistemological framing and pressed for him to accept their framing. This could be interpreted as delineating their framing of their positions themselves with higher epistemic authority than June.

Table 9. Discourse showing the restriction on June's presentation of reasoning 2 (Lesson 5, 'Observation of the leaf tissue' activity)

Line	Speaker	Discourse
820	Jane	You can go first.
821	Lin	(Tapping on June's worksheet) Hey, tell me your claim.
822	June	My claim is, claim is that Side B is the upper side.
823	Jane, Lin	Why is that so?
824	June	Because, Side A has large pores, which are stoma, and I thought these little cells are epidermis. And Side B is really dark, which is because . . . chloroplasts are concentrated in this part.
825	Yoon	(Laughing and talking with students in the other groups)
826	Lin	(Yawning right after June's utterance)
. . .		
830	Lin	I also thought Side B is the upper side.
831	Jane	(Nodding at Lin's words) Right.
832	June	(Talking with students in the other group)
833	Lin	That's because, you can see the upper side is dense; this is because it's palisade parenchyma, so (cells are) concentrated in this part. And this is like a sponge, and there are stoma here, see these circles here, it's just like the cell structure that Ms. C showed us before. So Side B is the upper one.
834	Yoon	Is it correct that the stoma is on the lower side?
835	Lin	Yes.
836	June	Guys, guys.
837	Yoon	Our nostrils are also on the lower side.
838	Jane	(Laughs)
839	Yoon	(To Lin) For real.
840	June	Guys, by the way, people say that, hey, I'm . . .
841	Jane	(Covering up her ears) Yoon's talking right now.
842	Yoon	Yeah, June.
. . .		
845	June	(To Yoon) Anyway, continue.
846	Yoon	Okay, anyway, because Side B has more chloroplast, it's darker, so I thought Side B is the upper side.
847	Jane	The reason that I thought Side B is the upper side is, uh, because palisade parenchyma and epidermis have more chloroplast, they are darker, so they are the most (( )), and palisade and spongy parenchyma are in (( )) of the leaf.
848	Lin	(Nodding at Jane's words)

The students shifted the epistemological framing of the argumentation activity to restrict June's participation, indicating that they understood June's intention to be accepted as a contributor to the discussion from his presentation of the reasoning. However, they did not want to accept him in the discussion; thus, they shifted their framing, monitored June's practices, and pressed him to accept their framing, thus maintaining their positional framing. These practices constrained June's agency by limiting his opportunities to express his thoughts and collaborate with the other group members in the discussion.

Acknowledgment after rebuttal

When June presented cognitive resources, a critical evaluation of his idea occasionally followed the initial 'rebuttal' to June's idea. The following discourse in the fifth lesson is a representative example (Table 10).

In the discussion, June presented his inference of which structure in the leaf tissue corresponded to the structure in the microscopic photograph (line 321). However, his idea was immediately corrected by Jane, who interrupted before June's utterance was finished to refer to the location of the spongy parenchyma (line 322). The information about the location of the spongy parenchyma raised by Jane was revised by Lin, and the discussion concluded with June admitting that the abovementioned reasoning was valid (line 328). Discussion following an immediate rebuttal of one of June's conceptual ideas also occurred in other contexts. For example, when June presented his inference of the distribution of the chloroplast (line 481), Jane immediately rebutted June's idea; however, with Lin's revision following Jane's words, June's idea became more sophisticated in the following discussion (lines 481-487).

Table 10. Discourse showing the acknowledgement after rebuttal on June's presentation of reasoning (Lesson 5, 'Observation of the leaf tissue' activity)

Line	Speaker	Discourse
321	June	Wait, the cells are irregularly . . . (distributed, so) this might be spongy parenchyma. This part seems irregular.
322	Jane	(In a conclusive tone) Palisade parenchyma on in the lower side.
323	Lin	(In a small voice) Isn't it on the upper side?
324	Jane	It's on the lower side. This, this is palisade parenchyma.
325	June	Oh, it's more like a middle part. So it's in the middle part.
326	Lin	(Nodding, in a low voice) In the middle part.
327	June	(Pointing at Side A in the photograph) This part, palisade parenchyma.
328	Jane	That's palisade parenchyma . . . Huh, that's right.
329	Yoon	What is right?
. . .		
481	June	Oh, wait. But if there're chloroplast here, then these small particles . . .
482	Jane	(Interrupting June's utterance, speaking rapidly) There are chloroplasts here but they are small.
483	Lin	(Immediately following Jane's words) Pores, these are pores.
484	June	Oh, these are pores (in a voice that gets lower).
485	Lin	That's why they are round.

Even if a productive discourse followed June's presentation of his idea, a preemptive rebuttal of the mistakes in June's idea occurred first. The students used a conclusive and assertive tone of voice for rebuttal, which delineated their intention of being in a position to convey their "correct" knowledge to June, rather than accepting the potential of June's idea. These features of their responses to June indicated their framing of their position themselves as higher epistemic authorities than June.

The students did not want to accept June as a contributor to their group argumentation, and June received this message. This interpretation was supported by the interview after the fifth lesson. In the interview, I asked the students what type of ideas June had presented in the group discussion, and June replied, "I did

not share my ideas with them." I asked why he had not explained his ideas, and June said, "They didn't ask me. . . . When I try to do something, you [Yoon] always say that you haven't asked anything." Therefore, June felt that the other students had not given him the opportunity to participate in the discussion. In contrast, Yoon said, "No, I wasn't saying that I didn't ask you. We were talking each in turn, and you didn't tell us yours in your turn. . . . I said so ["I didn't ask you"] only when you talked about nonsense." This shows that Yoon did not find June's idea useful in the discussion, suggesting the students' view of reducing June's epistemic authority.

However, as shown in the above discourse, when the other students immediately rebutted June's idea, June's idea was nonetheless brought into the zone of the other students' discussion, which led to their critical evaluation of its validity. This critical evaluation afforded the opportunity for June's idea to be acknowledged as a contribution to the development of a group argument.

5.5.2 Presenting the epistemological framing of the argumentation activity

The second discursive move was June's presentation of his epistemological framing of the argumentation activity. The discussions following this agentic discursive move showed the conflicts between June and the other students. This agentic discursive move could have been interpreted by the other students as pushing for changes in their epistemic practices. This is because the delineation of what students are expected and supposed to do is a discursive strategy used by teachers that helps them maintain their authority in the classroom (Gore, 1995). This teacher's discursive strategy could have been interpreted by the other students as June framed his position as one of the contributors in developing

the group's activity. This framing contradicted the other students' framing, which often led to conflicts in discussion, constraining June's agency.

Restriction and rebuttal

When June delineated his epistemological framing of the given argumentation activity, the other students usually restricted or rebutted June's framing. The following discourse excerpt occurred during the argumentation activity about 'light intensity and photosynthesis' (Table 11). In this activity, an experiment about light intensity and photosynthesis was shown in the student worksheet. Then, two examples of knowledge claims (Tom's and Emma's arguments) explaining the results of the experiment were provided. Tom's argument suggested the relationship between light intensity and photosynthesis as reasoning that buttresses the proportional relationship between light intensity and photosynthesis. Emma's argument was justified by the relationship between light intensity and photosynthesis as well as with inferences that light is an energy source of photosynthesis. The students were asked to critically evaluate Tom and Emma's arguments and to select the more persuasive argument.

In the discourse, Yoon, Jane, and Lin negotiated their framing of the given task and built a common understanding of what they needed to discuss in this activity. Jane tried to determine the difference between Tom's and Emma's arguments (line 145), which were revised by Yoon and Lin. Yoon and Lin rebutted Jane's understanding that Tom and Emma's arguments were justified based on different features of light. Then, the students reached an agreement that the two arguments were both based on the same experimental results (lines 151, 152).

Table 11. Discourse showing the restriction and rebuttal on June's presentation of his epistemological framing (Lesson 7, 'Light intensity and photosynthesis' activity)

Line	Speaker	Discourse
145	Jane	So, Tom's talking about light intensity. And is Emma talking about the distance of the light from the plant?
146	Lin	They are both talking about the same thing.
147	Jane	No, they are not. Tom first said that 'this experiment manipulates light intensity,' and Emma first said that 'this experiment manipulates the distance between the light and the plant.'
148	Yoon	No, they didn't.
149	Lin	Tom discussed the distance. He said, as the distance gets closer, . . .
150	Yoon	(Overlapping Lin's words) Light intensity increases as the distance gets shorter. And light intensity decreases as the distance gets longer.
151	Lin	They both did the same experiment.
152	Jane	(After looking at her worksheet for 17 seconds without any words) They are both correct.
153	Yoon	(( ))
154	June	They are both correct, but aren't we supposed to discuss who is more correct?
155	Lin	(While working on her own worksheet) Which one is more 'persuasive'
156	June	So they are both correct, anyway.
157	Lin	Yeah, they are both correct, anyway.
158	June	(After silence for 8 seconds) I think Emma's argument is more persuasive.
159	Lin	(Writing on her worksheet) Then, write that down (gradually raising her voice)
160	June	What did you guys write?
161	Lin	I just (stopping writing on her worksheet and looking at June), write your thoughts first and then we will have a meeting.
162	June	(Looking at Jane) What did you write?
163	Jane	(Bluntly) Why would I tell you that?
164	Lin	(Covering her worksheet to hide it from June, and knocking on June's desk, annoyed) Write down your thoughts. We will discuss soon. That way, we can more (( )).
165	June	(Annoyed) Why are you talking like that to me? They didn't write anything either (pointing at Yoon and Jane).
166	Yoon	(Looking at June, annoyed) I'm thinking now. But you are making noise.
167	Lin	(Annoyed) That's so true. Stop asking us.

June tried to engage in this discussion, suggesting that the group needed to focus on which argument was ‘more correct,’ not on which one was correct (line 154). This indicates that he had framed the activity as ‘choosing a ‘more correct’ argument’ and that the other students’ discussion had deviated from this framing. He showed that his framing was more appropriate for this activity, suggesting the necessity of redirecting the discussion accordingly. Lin rebutted June’s framing by saying that the activity was to ‘choose a more persuasive argument,’ attempting to revise the framing presented by June (line 155). Then, June reiterated his framing, claiming that his comments were valid (lines 154,156) and pointing out that his comments contributed to correctly understanding the given task. However, the students did not respond to June, and they were silent for a while.

Later, June argued that “Emma’s argument is more persuasive,” using Lin’s term “persuasive,” and he tried to resume the discussion (line 158). However, Lin replied, “Then, write that down” (line 159), ignoring June’s framing of the activity as a collaborative discussion. Lin’s words transferred shift to framing the activity as the ‘accumulation of an individual idea on one’s own worksheet.’ June continued to ask for other students’ ideas (lines 160, 162), reflecting his framing of the activity as a collaborative discussion. The other students shared Lin’s framing, writing their individual opinions in the worksheet without responding to June’s request for participation in the discussion (lines 161, 163, 164, 166, 167).

In the discourse, June delineated his epistemological framing, which indicated that he accepted Lin’s framing by using the expressions that Lin used before, and he called for a change in the ongoing participation pattern. In contrast to the discussion following the first discursive move, even though the students recognized that June’s framing was valid, they still limited the opportunity for June

to delineate his framing. It can be inferred that the students acknowledged June's framing as a contribution; however, they did not want to recognize his epistemic authority. In particular, when June asked to share ideas, Yoon framed June as a student who "makes noise" (line 166). This interaction between June and the other students shows conflict in their framing of June's position in their group work.

June's presentation of the epistemological framing could be interpreted as an attempt to lead the discussion and as delineation that he possessed a more "correct" understanding of the given activity. This discursive move could have transferred June's epistemic authority by showing that he was capable of judging suitable epistemic practices and leading the discussion as well as engaging in the discussion (Danielsson *et al.,* 2018). However, the other students delineated the misalignment of their framing with June's by restricting or rebutting June's framing to maintain their positional framing and to not accept June in their discussion.

Acknowledgment

The students occasionally acknowledged June's contribution when June's framing corresponded with the features of scientific argumentation or when it pinpointed the focus of the given task. This aspect suggests that the context of argumentation activity can enable marginalized students such as June to be accepted by other students in discussion. The following discourse excerpt shows this type of interaction (Table 12). Before the discourse, Ms. C noticed that many students' discussions were focused on the authenticity of the content on the evidence card. The students were searching for the "scientifically correct" content, reflecting their framing of the activity as 'finding the correct answer.' Therefore, she told the class, "Hey, guys, all the information on the evidence cards

Table 12. Discourse showing the acknowledgement of June's presentation of his epistemological framing (Lesson 7, 'Light intensity and photosynthesis' activity)

Line	Speaker	Discourse
566	Jane	Ms. C just told us that everything on the evidence cards are the facts.
567	Yoon	Oh, they are the facts?
568	Jane	Yeah.
569	June	(In an irritated and loud voice) Of course they are the facts. But aren't we supposed to choose more suitable ones for this claim?
570	Jane	(With anger) We need to choose the one that BEST JUSTIFIES the claim, JUSTIFIES.
571	June	(In a loud voice) That's what it is.
572	Jane	(Eyes wide open, with a straight face, to Yoon) Is that what it is?
573	June	(Laughing) June's right this time.
574	Jane	Oh, really?
575	June	I didn't want to admit it [June's framing] either, but . . .
576	Jane	(to Yoon) Are you sure?
577	Yoon	Why not! (( )) You should admit it.
578	June	(Laughing) I'm kidding [when I said that I don't want to admit June's words (line 575)].
579	Jane	Does 'justifying' mean that (choosing more suitable evidence card for the claim)?
580	Yoon	It's kind of like that. It's about finding the right one among many facts.
581	Jane	(Amazed) Oh~

Words in capital letters: denote the speaker's emphasis.

is true," to support the students in focusing on developing reasoning based on the information on the evidence cards. Then, the discourse in the Table 11 occurred.

In the discourse, the negotiation of epistemological framing began with Jane informing the group members of the teacher's words (line 566). Then, June said that Jane's words were obvious and revealed his framing regarding the use of the evidence cards in the activity, which is 'to choose the ones that are "more suitable" to the claim they argue for' (line 569). Jane rebutted June's explanation by stating that they needed 'to choose the ones that "justify" the claim they argue

for,' but June said that Jane's revision was not very different from his (line 571). June's words indicated that Jane's revision of the expression did not contribute much to improving their understanding of the activity. This sparked Jane's strong opposition, and Jane asked for consent to her opposition (line 572). However, Yoon supported June, and Jane accordingly also showed acceptance (line 573). In this discourse, June attempted to be acknowledged for his contribution by showing that his understanding of the given activity was more appropriate, which was recognized by Yoon.

Jane's correction on June's framing was closer to describing what the researchers and Ms. C intended with the use of evidence cards. However, Yoon seemingly agreed with June's framing because he interpreted that both June's framing and Jane's framing are both indicating the same epistemic practices of selecting the evidence cards that matched the claim. Therefore, Yoon acknowledged the validity of June's understanding of the activity, and June's framing was shared by the other students. While the students delineated their epistemological framing, i.e., their understanding of how they were expected to participate in the argumentation activity, and justified their framing, they were able to reflect on the specific practices that they do in argumentation activities and improve the sophistication of their understanding of the argumentation activities in science classrooms.

While accepting June's framing, the students still showed their resistance to acknowledging June's contribution. This inference was supported by Jane's attempt to justify her framing based on her bonding with the other students except June. She relied on her shared positional framing with the other students rather than justifying why her framing was more valid than June's. In addition, Yoon explicitly

revealed that his agreement with June's framing was not what he wanted by saying "I didn't want to admit it [June's framing] either" (line 575). Nevertheless, Yoon supported June's argument, and his utterance in line 573 ("June's right this time") explicitly delineates that Yoon has evaluated whether June's framing is "right." Based on his agreement with June's framing, it seemed that Yoon's evaluation was more focused on the actual practices in which the students would engage as participants in the argumentation activity in the science classroom rather than the superficial expression of those practices.

5.5.3 Presenting a reflection on previous epistemic practices

The last discursive move was for June to infer the epistemological framing from the ongoing discussion, compare it with his own epistemological framing, and present this reflection in the discussion. This agentic discursive move indicated that June used his epistemological framing as the standard for reflection and regarded it as valid. In addition, the explicit delineation of the reflection implied a call for other students to shift their ongoing epistemic practices. It seemed that this discursive move was interpreted as June's framing of his position with the epistemic authority to evaluate other students' epistemic practices and placing the other students' practices as subjects for evaluation.

Rebuttal

In the discourse in Table 13, the students rebutted June's reflection and limited his contribution of ideas to the discussion, constraining June's agency. The discourse appeared in the 'transportation of water through xylem' activity in the fourth lesson. The students were asked to predict the color of the leaves when the

Table 13. Discourse showing the rebuttal to June's reflection on the previous epistemic practices (Lesson 4, 'Transportation of water through xylem' activity)

Line	Speaker	Discourse
1059	Jane	Now, starting from you (tapping on June's desk), share your idea.
1060, 1062	June	The color would not be . . . purple (( )).
1069	Lin	I think it's going to be purple, because there's a thick vein in the middle (moving hands from the center outwards), and then like this [thin leaf veins spread to both sides]. So I think they [blue and red water] will gather together in the middle. Now it's your turn (pointing at Yoon).
1071, 1073	Yoon	Okay. . . . I think it's going to be half and half [red color in half and blue color in half of the leaf] like Harley Quinn['s hair]. . . . Because this [red and blue water] goes up [through the stem] and splits up later.
1074	Jane	Oh~
1075	June	So, am I right?
1076	Yoon	Right, but I didn't really pay attention. June (turning away his head from June), I'm sorry.
. . .		
1119	Ms. C	. . . Let's choose the most plausible idea in the group and share that idea in the whole-class discussion. . . .
1121	June	In my perspective, Yoon agrees with my idea. . . . Guys, guys, can't we present mine in the whole-class discussion? He really agreed with mine.
. . .		
1125	Lin	Let me show mine, I want to show mine.
1126	Jane	Let's go with Lin's.
1127	June	Uh, but Yoon really supports mine.
1128	Yoon, Lin	(Talking about other things, not listening to June)
1129	June	(Knocking on the desk, to Jane) Hey.
1135	Jane	(In a low voice) I didn't mean that. . . . (( )) I didn't mean that yours can be presented . . .
. . .		
1139	June	(Raising his voice) It's a good one, though. We can just try it.
1140	Jane	(In an angry voice) Hers (Lin's argument) is better.
1141	Lin	Right. Mine's better.
1146	June	But Yoon said that he supported mine. It doesn't make sense [to ignore that support].
1147	Jane	But he's the only one . . .
1148, 1150	June	Is there anything else to say? . . . (In a loud voice) Yeah, bring it on, bring it on.
1151	Jane	(In a calm voice) Only he supported yours, not us.
1152	Lin	Just shut up.
1153	June	Uh, but . . .

Table 12 (continued)

1154	Lin	(In a loud voice, interrupting June's utterance) Ahhhhhh~
1155	Yoon	June, I wasn't agreeing with your idea. I just wrote down my idea.

stem of a lily is divided in half and the halves are soaked in red- and blue-pigmented water.

At the beginning of the discourse, the students presented their individual arguments in order (lines 1059-1076), and June obtained agreement with his idea from Yoon. When Ms. C asked for the students to develop a consensual argument in each group, June suggested that he present his argument as the group's consensual argument in the whole-class discussion after the group activity (line 1121). However, Lin also suggested that her idea be presented in the whole class discussion (line 1125), and June began to face opposition from the other students. June insisted that his idea should be presented 'because it was supported by another student'; however, Jane and Lin rebutted by replying that they supported Lin's idea but not June's (lines 1140, 1141, 1151). Moreover, Jane and Yoon reinterpreted their former utterances in line 1076, limiting June's attempt to justify his idea (lines 1135, 1155).

When Ms. C asked a presenter to stand up in each group, Lin stood up to show her willingness to present her idea. June tried to stand up at the same time but sat back in his chair, saying "Okay, I'll let you do it this one time." The other students pointed out the expression 'let you do it,' and afterwards, the group discussion ended as the whole-class discussion began.

June argued for the validity of his idea based on Yoon's support. This indicates that he has framed the argumentation activity as 'reaching a consensus by earning other participants' agreement.' To rebut June's insistence, the other students

argued for the validity of Lin's idea, using the framing delineated in June's words. Furthermore, they reinterpreted Yoon's previous utterance (line 1076), suggesting that Yoon did not agree with June but was simply sharing his individual idea (line 1155). With this rebuttal using June's framing, the students tried to stop June from presenting his idea as the group's opinion.

It seemed that framing as 'reaching consensus by earning other participants' agreement' was a response to the students' interaction with Ms. C or the researchers. The students were introduced to the dialogical features of the argumentation activity in the first lesson (Table 6). After the first lesson, Ms. C tried to facilitate the students' participation in discussion when she intervened in each group's work. Additionally, in the interviews with the researcher, the students were asked to share their ideas, critically evaluate each other's ideas and further develop the reasoning they had discussed in class and were asked whether they all agreed on the developed reasoning. The students' framing of valuing the earning agreement of other students indicates a reflection of the dialogical features of scientific argumentation. Furthermore, the reflection of the dialogical feature in the framing shared by the students implies that the students have acknowledged the authority of scientific argumentation.

Although the students, including June, shared the same epistemological framing, their reflections on the previous practices differed. This difference was seemingly the reason for the students' opposition to selecting June's idea as a representative product of their group. In other words, the students did not acknowledge that June's idea possessed the possibility of being valid for use in developing communal knowledge, unlike their own ideas, undermining June's epistemic authority. Therefore, to justify this initial opposition based on their

positional framing and constrain June's agency, the students suggested rebutting June's opinion, while sharing his epistemological framing.

Acknowledgment

The discourse in Table 14 shows how the students acknowledged June's reflection on their epistemic practices. June's practices in this discourse were distinguished from those in the previous discourse because he reduced his epistemic authority and asked the other students to improve the sophistication of the previously suggested idea. The discourse occurred in the 'girdling' activity in the eighth lesson.

In the girdling activity, the students received a picture showing a tree that had been peeled so that the top part of the tree bulged. The students were asked to develop an argument to explain this phenomenon. The students began the discussion by sharing individually built arguments in order. Then, June said, "Which one do you think is better? Mine and Lin's [arguments] are identical. . . . Which one [between June's and Jane's] is more persuasive and precise?" (lines 134, 136), pressing for a discussion of the validity of the shared ideas. However, Lin rebutted this suggestion by saying, "Can't we just merge all the ideas?" (line 137). Jane subsequently agreed with Lin.

Lin and Jane aligned to frame the group discussion as a 'simple accumulation of the group members' individual ideas' and did not agree with June's framing. Thus, June's framing of the activity once again conflicted with that of the other students. He framed the activity as 'critical evaluation of individual ideas to develop the consensual argument'; however, the other students did not agree with this framing. June continued the discussion by saying, "You mean, just add them all?" (line 139), and the misalignment in their framings was then resolved in the following discourse.

Table 14. Discourse showing the acknowledgement to June's reflection on the previous epistemic practices (Lesson 8, 'girdling' activity')

Line	Speaker	Discourse
144	June	Honestly, I can't really grasp what Jane said.
145	Jane	Look, look. The growing points got ripped off, right? So, the tree bulged up to recover it [the growing point].
146	Lin	So if we get hurt, it gets healed again. Like that, the tree bulged up while healing again.
147	June	Oh, so the bark getting peeled off means that the tree got hurt?
148	Lin	Yes.
149	Jane	So, it swells up to recover that part. . . .
150	Lin	But once the bark is peeled off, it can't be recovered.
151	Jane	But maybe apple trees are like that. (Laughs)
152	Lin	Oh, apple trees are. (Nods)
153	Jane	What did you write?
154	June	The water goes up by osmosis and transpiration. But saying that the water goes down because of gravity makes no sense.

In line 144, June asked Jane for elaboration because he "can't really grasp" her idea. Jane responded to June's request by elaborating on the idea she had shared earlier, and she also asked about what June had shared before. The discourse is different from the discourse in Table 12 in which June's framing was inconsistent with the other students' framing. In this discourse, June continued to indicate his framing as a 'critical evaluation of individual ideas to develop the consensual argument' and pushed for a shift in the other students' framing. At the same time, he requested more information from the other students. This could be interpreted in two ways. First, he allowed the other students to position themselves as sources of information, further explaining their ideas to June. Second, the other students might have thought that no further discussion was needed and that they had already developed a consensual argument. By saying "I can't really grasp what Jane said," June suggested that he might have incorrectly reflected on the previous

discussion. In this way, he invited the other students to position themselves as epistemic authorities who could modify his reflection on the previous discussion. June's utterance contributed to reducing the collision with the other students, and he was accepted in the discussion as the group developed a communal argument together.

5.6 Discussion

In this study, based on Emirbayer and Mische's (1998) perspective on agency, I identified agentic discursive moves in which the marginalized student attempted to be accepted by the other students in his group. In addition, in the discussions following such discursive moves, I explored how the students negotiated their framings of the argumentation activities. Based on these findings, I discussed how the marginalized student's epistemic authority was shown by his agentic discursive moves, how the other students restricted or afforded it, and how the context of the argumentation activity influenced this process.

5.6.1 June's agency in the context of the argumentation activity

June's agentic discursive moves were categorized among three types: (a) presenting reasoning based on the activated cognitive resources; (b) presenting his epistemological framing of the argumentation activity, pushing for the activation of resources that corresponded to his framing; and (c) presenting his reflection on the previous epistemic practices based on his epistemological framing. Referring to teachers' discursive strategies that help them maintain epistemic authority in the classroom (Gore, 1995), I inferred how each discursive move would be interpreted

to imply June's framing of his own position by the other students.

The first type of discursive move was the move most commonly practiced by June throughout the activities, and in many cases, it was restricted by the other students. This discursive move has also been depicted in other studies mainly to demonstrate marginalized students' active engagement in discussion and the activation of their cultural resources (e.g., Barton & Tan, 2010; Sharma, 2007; Stroupe, 2014). In particular, Sharma (2007) described agency in terms of students' enactment of their experiences in the discussion of scientific concepts. This is similar to June's activation of his cognitive resources in the group discussion. This discursive move showed that June was capable of engaging in the discussion and that he could be positioned as a contributor to the discussion with other students.

The second and third discursive moves were the types that mainly appeared after the fifth activity. These discursive moves are important in terms of building and transforming the structure of the activity, to be more precise, the schema of the activity. The prior studies that have discussed agency in this way include Basu *et al.* (2009); Stroupe *et al.* (2018); and Tan & Barton (2008). For example, these discursive moves are similar to students in socially marginalized groups devising activities in which they can act as active participants (Basu *et al.*, 2009). Additionally, they are similar to the moves of students who proposed a new data collection method in an ecological research project in a study by Stroupe and associates (2008). Furthermore, they are similar to Tan and Barton's case study (2008) that showed how a student activated resources that deviated from the existing interaction patterns and promoted new participation patterns that were acknowledged by other class participants.

In these previous studies, the teachers played an important role in recognizing the value of the resources activated by the students, encouraging the whole class to accept such resources in their activity. However, in the case of this study, such a role was inevitably limited because the teacher also had to visit and support other small groups' discussions. In this situation, the students were supposed to shape the structure of their group work, which used to be the teacher's role and authority in the traditional classroom. They needed not only to activate resources but also to justify and evaluate the value of the activated resources as a contribution to the group work. In other words, the group members, including the marginalized student, acted as agents who negotiated the structure of the activities.

June commonly aimed to position himself as an accepted member of the group; however, other students' framings of June's position seemed to vary according to the discursive move. The second discursive move indicated that June was not only capable of participating in the discussion, but could also set expectations and goals for the students' epistemic practices in the activity. By showing the last type of discursive move, June not only guided the expectations and goals of the discussion but also delineated his evaluation of the other students' practices. Then, he asked for elaboration of the previously presented ideas according to his own framing of the activity. In reference to the discussion on how power is exercised through knowledge in school (Gore, 1995), providing goals for learning activities, reviewing students' ideas, and prompting modifications based on one's own standards are usually what teachers as epistemic authorities have traditionally done in classrooms (Danielsson *et al.*, 2018; Donnelly *et al.*, 2014). In other words, the second and third discursive moves can be interpreted as attempts to position oneself as a higher authority than other students. This is in contrast to

the framing of the other students, who reduced June's epistemic authority, which led to collisions such as explicit rebuttals of June's resources and framings, constraining June's agency.

5.6.2 Affordances and constraints on June's agency in the context of argumentation activity

Small-group argumentation activity provided a context for the students to delineate their social relationships and negotiate their positions in the development of knowledge. The discussion following each of June's agentic discursive moves showed the other students' perception that June did not possess valid epistemological understanding or valid cognitive resources that could contribute to the process of constructing communal knowledge claims, thereby constraining June's agency. June's authoritative voice might have contributed to the other students' restrictions and initial rebuttals to June's ideas. Especially, the second and third discursive moves implied requests for changes in the existing discourse among the students. The Korean language reflects the hierarchical culture in Korea, where an authoritative and commanding tone of voice is usually expressed in the utterances of a person in a higher position. With the authoritative voice, these discursive moves could have been interpreted being issues with a commanding tone, leading the other students' frequent restrictions and initial rebuttals.

The students' evaluations of whether June's practices were appropriate based on their framing were consistent with how teachers maintain authority in the traditional classroom (Gore, 1995). These students' evaluation indicated that they perceived their understanding as more reasonable than June's and that they were trying to frame their positions with higher epistemic authority. The students'

rebuttal of June's attempts to be accepted in discussion resulted in the reconfirmation of June's marginalization.

The students shifted the epistemological framing of the argumentation activities to 'accumulation of an individual idea on one's own worksheet' when June tried to participate in their discussion, and this shift was shared and justified by the students except for June. The students' limitation of June's agency was in line with the discussion of Cornelius and Herrenkohl (2004) that partisanship among students has a strong influence on their social relationships and on epistemic activity. The findings of this study showed that the students, except for June, shared positional framing and formed the partisanship as colliding with June and uniting together to constrain the marginalized student's participation. The findings showed that this process could also lead to a shift to unproductive framing in argumentation activities.

However, there were occasions when June's idea was addressed in the discussion, beginning with a rebuttal of the idea that June presented. The immediate rebuttal of June's idea suggested that the other students interpreted June as framing his own position differently from the framing that they had been sharing. However, in contrast to not responding to June's words, the rebuttal opened up the space for discussion of the validity of their epistemological framing or resources. In the discussion, June justified the validity of his ideas to be accepted by other students. He used Ms. C's explanation of the activity and his understanding of "scientific argumentation" as criteria for the justification. June's justification played an important role in June's exercise of agency and his being accepted as another collaborating group member by the other students.

In the discourse in which June presented his reflection on the previous practices and was acknowledged by the other students, June asked the other students to supplement his understanding with more elaboration of their ideas. In this way, he presented his reflection as something that could be modified, providing room for other students to modify his reflection. His words still implied his monitoring of the other students' practices; however, he acknowledged that the other students were also able to monitor and reflect on the discussion based on their own epistemic understanding. In other words, by opening a space where other students' epistemic understanding could also function as power, June's words facilitated the discussion with the other students. The utterance itself seemed to be merely a request for more information from the other students; however, June was able to reflect his framing in the discussion and to be accepted in the discussion by the other students with this utterance.

The other students' responses to June's agentic discursive moves both afforded and constrained his agency. In particular, when their discussion focused on the validity of epistemological framing or the arguments presented, June was given the opportunity for them to acknowledge his epistemic authority, and the students were able to improve the sophistication of their framing of the given argumentation activity. This suggests that the argumentation activity in the science classroom provided a context in which June could transform his social relationships and interaction with the other students.

5.6.3 Reflection of scientific argumentation in the students' negotiation of the framing

June's practices that reflected his agency and the reasoning that he provided were able to be acknowledged by being justified and evaluated as consistent with scientific concepts or the epistemic practices of scientific argumentation. Ms. C's guidance and the interviews with the researcher seemingly influenced the students' understanding and recognition of the authority of scientific argumentation. There was a brief introduction to scientific argumentation in the first lesson, and Ms. C led the small-group discussions with an emphasis on the dialogical features of scientific argumentation (Ford, 2012). Additionally, she provided space for the students to improve the sophistication of their understanding of the activity through group discussion. For example, when she noticed that the students' discussions were focused on the authenticity of the content on the evidence card, she told to the class, "Hey, guys, all the information on the evidence cards is true." This comment led the students to think about what they were expected to do in this activity and to negotiate their framing. In this discussion, Ms. C's guidance of the argumentation activity served as criteria for the validity of each other's ideas. The discussion where June wanted his idea to be presented in the whole-class discussion showed the students' sophisticated criteria for choosing the representative argument of the group, reflecting the dialogical features of scientific argumentation in the discussion. Furthermore, in the interviews after each class, I asked questions that mainly explored the students' epistemic understanding and social relationships in the group discussion, creating a context in which the students recognized and valued the epistemic authority of scientific argumentation.

However, consistency with disciplinary practices and scientific concepts did not immediately lead to acceptance of June in the discussion. In many cases, when June delineated his reasoning or epistemological framing, the initial response was restriction and rebuttal followed by the reflection on scientific argumentation in the evaluation of the validity of his thoughts.

June relied on the authority of disciplinary knowledge and practices to justify his framing and the validity of his cognitive resources. The students compared alternative opinions on what reflected more aspects of disciplinary knowledge, which provided opportunities for June's ideas to be acknowledged. The criteria for evaluation, in turn, led more authority to disciplinary knowledge and practices, bringing the students' practices closer to the disciplinary norms of scientific argumentation. Through this process, the students tried to position themselves as authors of knowledge, while reflecting the dialogical features of scientific argumentation. These findings are in line with the discussion about disciplinary agency that have argued that humans are relatively passive in terms of following the culture of a particular academic discipline (Gresalfi *et al.*, 2009; Pickering, 1995). Furthermore, these findings also demonstrate how disciplinary knowledge can serve as a criterion for students' negotiation of their positioning and how it supports the discussion by Foucault (1977), who argued that accumulated knowledge itself acts as a form of normalizing power. During the students' negotiation of their positioning and the structure of the argumentation activity, they were able to delineate not only their own authority but also the authority of disciplinary knowledge and practices.

The image of 'scientific argumentation' seemed to become more sophisticated in the students' discussion. In particular, the discussion following

June's second and third discursive moves showed an evaluation of the validity of June's framing. The criteria for this evaluation were the students' personal understanding of what is expected from argumentation activities in the science classroom, which reflected the dialogical features of scientific argumentation. Thus, the students were able to compare alternative understandings of the given activity, focusing on which one reflected more aspects of disciplinary practice. In this way, they improved the sophistication of their shared understanding of argumentation activities in the science classroom. This can be interpreted as the discourse that delineates a fine line between particular concepts by privileging certain practices and excluding others (Foucault, 1971). While from the beginning, the students participated in the activity with a recognition of the epistemic authority of 'scientific argumentation,' their specific understanding of it became more sophisticated. June's agentic discursive moves to position himself as an accepted member of the group facilitated these discourses of negotiating and increasing the sophistication of the students' framing of argumentation activity. The findings of this study open the possibility of explaining how a unique culture can be created for a learning community in a science classroom while reflecting the culture of scientific argumentation.

These findings also indicate that the students might not have acknowledged the authority of scientific argumentation based on their understanding of what "scientific argumentation" is. Additionally, this could explain why the students' discussion was vulnerable to shifts according to other aspects, such as their partisanship, which frequently caused a shift to unproductive framing. These findings indicate that we need to explore students' negotiation of the structure of science learning activities in terms of how they recognize the epistemic authority of disciplinary activity.

5.7 Chapter Conclusion

This study explored student agency in his attempts to be accepted in discussions with other students in argumentation activities in a science classroom. In this section, I address several implications of this study.

First, this study identified student's agentic discursive moves in his attempts to be accepted by the other students in their discursive interaction in the context of the argumentation activity. Many of the prior studies on agency have focused on the difference in epistemic authority between teachers and students, exploring how students as a group showed epistemic agency, or they have focused on marginalized students' activation of their own cultural resources. In these studies, student agency has mostly been discussed in terms of students' activation of resources (e.g., Barton & Tan, 2010; Sharma, 2007; Stroupe, 2014). Based on these studies, this study explored a marginalized student's discursive practices in his attempts to transform the activity structure through discursive interaction with other students. The findings show that we need to discuss student agency in the process of students' negotiation of the framing of the activity as well as their activation of resources to understand their collaborative development of discussion. In addition, the three discursive moves identified in this study can be used as a framework for exploring students' transformative agency in the context of argumentation activity in the science classroom. The agentic discursive moves that were identified in this study can provide teachers ideas about which practices can be useful for identifying student agency in argumentation activities.

Second, based on Gore's (1995) discussion of the formation and maintenance of teachers' epistemic authority in classroom discourse, this study explored why students negotiated and transformed the structure of argumentation

activity in a certain way. The findings show how the students' positioning, closely related to their social relationships outside the classroom, affected a shift in their epistemological framing and how the marginalized student's framing was shared or not shared by the other students. The preceding literature on argumentation activity in the science classroom has discussed how argumentation activities can be a context in which students position themselves as epistemic agents. This study showed that the argumentation activity can instead be a context in which the students' social relationships outside the classroom are revealed as they participate in social interaction for the development of knowledge claims. Considering this point, this study explored the dynamics of the students' negotiation of participation patterns and epistemological framing, extending the discussions of the previous studies.

Third, this study showed the potential of dialogical argumentation activity as a context in which students delineate their social relationships and form a positive identity. The students justified and evaluated their practices with their understanding of 'argumentation activity in the science classroom.' The findings show that these criteria played a significant role in the acknowledgment of June's idea by the other students. In other words, emphasizing the epistemic authority of scientific argumentation was at the center of the students' agency and their negotiation of framing in the following discussions. Future studies can examine in more detail how students recognize the authority of argumentation activities and how this recognition influences the changes in their positioning in the process of forming learning communities in science classrooms.

Finally, this study expanded the results of previous studies that have explored the classroom with a teacher's active support of minority students'

transformative agency. In this study, June's attempts to transform the structure were enacted through the negotiation of the structure with other students. This shows not only that teachers need to provide students with the space to participate as agents in activating cognitive resources but also that students need to recognize one another as collaborating agents. Therefore, it is necessary to provide opportunities for students to negotiate their positioning and the structure of the activity through discussion. At the same time, it is necessary to support the students in recognizing that all classroom participants can provide reasonable ideas rather than focusing on the inequality in their existing social relationships. I expect that future studies on instructional strategies to support this aspect will contribute to the construction of dialogical argumentation in the science classroom. Furthermore, I expect that this study can be extended by enacting studies that explore how students can form stable collaborative relationships among themselves in argumentation activities, contributing to the construction of a learning environment that supports the formation of collaborative learning community in the science classroom.

Chapter 6. Conclusion and Implications

6.1 Summary and Conclusion

This study identified student agency as a main feature that facilitated the students' shifts to positioning themselves as collaborative contributors in small-group argumentation activities in science classrooms. First, this study investigated how student agency has been explored and discussed in the literature. Based on these analyses, I developed an approach to discuss student agency as student's capacity to facilitate the negotiation of framing and how students negotiate their framing of argumentation activity in subsequent discussion. Then, based on this theoretical investigation, two case studies were conducted. The first case focused on a small group of students who acknowledged each other as collaborative contributors to the development of a communal argument through group discussion. This study demonstrated how student agency plays an essential role in facilitating a shift in students' shared framing. The second case study explored a small group of students with a marginalized student. The analysis of this case identified the discursive moves that reflected student agency that facilitated the negotiation of the framing of the argumentation activity. The findings of these studies can further our understanding of the role of student agency in the construction of a collaborative learning community in science classrooms.

To be specific, in the theoretical investigation of student agency, I explored which aspects of student agency had been investigated and the ways in which agent practices in learning communities had been investigated. The results of the investigation revealed five aspects of agency related to students' actions in a learning community: epistemic agency, transformative agency, educated action in

science, disciplinary agency, and material agency. The studies on epistemic agency focused on students actively participating in knowledge-developing discussion rather than being passive recipients of knowledge from other sources in the traditional classroom. Transformative agency was discussed in terms of students developing their positive identities in the science classroom and transforming a classroom structure that formerly constrained their positive identities. Educated action in science was defined as students taking actions with the intention of contributing to society in an activity addressing socioscientific issues. Disciplinary agency was discussed as an exploration of how students' practices in science learning reflect the culture and practices of the scientific community. Finally, the concept of material agency was used to underline that material also possesses agency, which influences students' epistemic practices and the knowledge they develop in science learning.

I also delineated the three approaches by which previous research has examined the practices of students as agents who construct learning communities. These approaches are as follows: (a) describing agency as a whole across the entire learning community, (b) describing the influence of a focused student's agency, and (c) describing interactions between agents.

Based on these analyses, I developed an approach to discuss students' discursive practices that reflect their agency and the negotiation of framing in ensuing discussion with other group members. The main aspects of this approach were as follows: (a) epistemic authority interpreted from the students' recognition of the participants' capability to contribute to the development of knowledge, (b) student agency in terms of the students' capacity to facilitate the negotiation of framing, and (c) the schema of an activity explored through the students' framing.

Based on this theoretical investigation of student agency, two case studies were conducted. In both cases, the argumentation activities were designed to facilitate the students' framing of the argumentation activity as a process of collaborative knowledge construction. In the argumentation activities, the students were asked to develop arguments with valid justifications, evaluate them in discussion, and reach a consensus. Semistructured interviews were conducted with the focus groups after each lesson. The students' discursive practices in class and their interviews were all recorded and transcribed for analysis.

In the first case study, I focused on the group that clearly showed a shift toward productive framing, that is, students' engagement in discussion for the development of communal arguments. Then, I investigated how the students negotiated personal framings of their positions and how this negotiation of framing was facilitated in the group.

The analysis showed that the focus group's interactions were initially focused on a student with higher epistemic authority. The student with higher epistemic authority, framed as an authoritative source, only responded to the other students' ideas, rather than proposing her own ideas. The students barely included one another, except for Hyun, as valid contributors to their discussion.

One student facilitated changes in this interaction pattern. She showed her intention to accept the other students' ideas and discuss them, which indicated her framing of herself and the others as proposer and critical evaluator. These attempts, which reflect her agency, were blocked by the other students who maintained their existing framing. However, she was able to initiate changes by forming a zone of interaction that was separate from that of the student with higher epistemic authority. The separate zone was initiated by her request for additional explanation

of the scientific concepts. In this separate zone, she was able to share her positional framing as a collaborative contributor with another student.

After forming separate zones of interaction several times, the zone expanded and all the group members began to share their ideas together. The students began to justify their claims with their own ideas. In addition, the students considered their ideas to be valid, sharing their positional framing of themselves and one another as collaborative contributors.

These findings suggest that the context that has been discussed as facilitating students' active participation can be more precisely described as facilitating the beginning of their negotiation of positional framings. Although the students activated their own resources, the students in the argumentation activities were discordant in terms of their personal framings at the beginning. Their shared framing as collaborative contributors manifested after the negotiation of their personal positional framings facilitated by a student's agency. The agent's attempts were initially resisted by the other students who persisted in their reliance on a student with higher epistemic authority. The agent was able to begin negotiating the framing in a zone of interaction that was separate from that of the student with higher epistemic authority and to share her framing with the group members later in the collective zone of interaction. The study empirically described how student agency plays an essential role in the shift in the student's shared framing of argumentation activity in the science classroom.

In the second case study, I focused on the group with a marginalized student who was not being accepted by the other students in the group discussion. I identified the discursive moves that reflected the student's agency. Then, I explored how the group members' framing of the activity was negotiated in the subsequent

discussion. Finally, I discussed how the argumentation activity in a science classroom affected the students' negotiation of the activity structure.

The student's agentic discursive moves fell under three categories. First, I described his presentation of reasoning based on his own cognitive resources. This discursive move was interpreted as showing his intention to prove that he was capable of contributing to the development of valid reasoning. The second discursive move was presenting his epistemological framing of the argumentation activity, pressing for epistemic practices that corresponded to his framing. The third discursive move was to infer the epistemological framing from the ongoing discussion, compare it with his own epistemological framing, and explicitly delineate such reflection in discussion. This discursive move indicated that he used his epistemological framing as the standard for reflection and implied a call for other students to shift their ongoing epistemic practices.

The other students' responses to the agent's discursive moves both afforded and constrained his agency. The discussion following his discursive moves showed that the other students perceived that he did not possess the valid epistemological understanding or valid cognitive resources that could contribute to the process of constructing communal knowledge claims. There were three features of the contexts in which his ideas were acknowledged in the discussion. The first was the rebuttal of the idea that the marginalized student presented followed by the acknowledgment of its validity. Although the immediate rebuttal of his idea suggested the other students' intention not to accept him in their discussion, it opened the door for the discussion of the validity of their epistemological framing or resources. The second was the acknowledgement shown after the marginalized student's justification of the validity of his idea. Additionally, when he asked the

other students to supplement his understanding by elaborating their ideas—presenting his thoughts as modifiable—he was accepted in discussion with the other students.

Most of the time, the student's agency was constrained. His practices and the reasoning he provided were acknowledged when he justified his ideas by stating that they were consistent with scientific concepts and the epistemic practices of scientific argumentation. The criteria for the evaluation of his framing, in turn, gave more authority to disciplinary knowledge and practice, leading the students' practices closer to the disciplinary norms of scientific argumentation. Through this process, the students tried to position themselves as authors of knowledge while reflecting the dialogical features of scientific argumentation. These findings introduce the possibility of explaining how a unique culture can be created for the learning community in a science classroom while reflecting the culture of scientific argumentation. However, these findings also indicate that the students might not have acknowledged the authority of scientific argumentation based on their understanding of what 'scientific argumentation' is. This aspect could explain why the students' discussion was vulnerable to shifts according to other aspects, such as the students' partisanship, which caused frequent shifts to unproductive framing. These findings indicate that we need to explore students' negotiation of the structure of science learning activity in terms of how they recognize the epistemic authority of disciplinary activity.

Based on the findings in these three sub-studies, this dissertation describes that student agency facilitates group members' framing of their positions as collaborative contributors to knowledge development in argumentation activities in science classrooms. The previous literature on student framing has shown how

students' framing can shift context-sensitively and the studies have explored instructional supports that can transfer a teacher's productive framing to students (e..g, Elby & Hammer, 2010). The findings of this study suggest that it is not just the instructional supports facilitating framing this shift but student agency also plays an important role in students shaping their discussion as dialogical argumentation. Even in a science classroom with argumentation activities that are designed for students' active participation in knowledge development, we can still see students who remain passive recipients of authoritative knowledge. Furthermore, there are many small groups of students who engage in active discussion when a teacher intervenes but stop the discussion without the teacher's presence. This study indicates the importance of facilitating students to not just hold epistemic authority but also to acknowledge other group members as collaborative contributors and to exercise agency by attempting to transfer such framing to them. I think that the instructional supports that facilitate student agency can support students' construction of their own knowledge-developing community in argumentation activities in science classrooms.

6.2 Implications and Recommendations

In this section, I address several implications and recommendations for practice and research in science education.

First, this study has shown that students' agency plays an important role in facilitating the shift to positioning themselves as collaborative contributors in small-group argumentation activities. This finding allows us to view students as agents who form the structure of the activity rather than simply reacting to contextual cues. The literature has delineated the contextual cues that encourage

students to perceive the potential of their own resources to contribute to valid knowledge in the science classroom. However, even with these contextual cues, we still encounter many students who persist in relying on receiving information from someone else. This study indicated that these contextual cues delineated in the previous studies are those that facilitate students' agency to initiate the negotiation of their epistemic roles through discussion. This study also indicated that it is necessary to investigate instructional support for a shift in framing and consider students' agency so that we can facilitate their negotiation of their positions as collaborative contributors.

Second, this study demonstrated that for students to participate in dialogical discussion, it is important for them to position themselves as collaborative contributors rather than merely a group of individual knowledge developers. This finding indicates that we need to focus on how to modify the power difference between teacher and students to investigate how students understand each other's epistemic roles and negotiate their understanding. Additionally, this finding indicates that we need to provide opportunities for students to negotiate their epistemic roles for their participation in dialogical argumentation activity.

Third, this study showed that a student's transference of framing shifts can vary depending on the student's positioning in the group, because the structure of the learning activity cannot be shifted by a single participant's agency. The structure is negotiated with other participants, and this study showed that the students' framing of the agent's position had a strong influence on the evaluation of the validity of his or her idea. This aspect suggests the need to explore contextual cues that take into account the framing of a student's position to facilitate a

productive learning community in the science classroom.

Fourth, this study identified the discursive moves of agents in attempts to be accepted in group discussion in science education. These discursive moves can be used in other studies to explore student agency in dialogical argumentation activities in science classrooms. Additionally, the adoption of Gore's idea (1995) to understand students' discussion following each discursive move can provide a basis for future studies exploring how the shift in personal framing leads to changes in the group framing or exploring structural changes in students' learning communities.

Finally, this study explored how student agency that facilitated shifts in students' framing can be afforded or constrained in subsequent discussions. This process allows us to view the structure of the activity as being transformed not solely by the agent but also by interaction with other participants. In this way, this study identified the dynamic shifts in the structure of the activity during the students' discussion. Future studies can explore and discuss how we can address this feature in supporting the construction of students' learning communities in science classrooms.

This study has several limitations. In this study, the teachers did not frequently intervene in the students' group discussion. In addition, due to the focus of the study, the teacher's role of providing initial guidance and support for students' participation in argumentation activities has not been discussed in depth. However, teachers obviously play an important role in science learning, and teachers can bring about enormous changes in students' epistemic practices in argumentation activities. Future studies can explore teachers' roles and their strategies in facilitating students' framing as collaborative contributors in

argumentation activities.

This study focused on student agency in attempts to be accepted as collaborative contributors and how student agency facilitates the negotiation of framing in discussions with other group members. Due to this focus of the study, the case studies focused on students whose agency was clearly shown in their discursive practices and their interactions with other group members. However, the other group members can also be described as agents who also contributed to the negotiation of framing. Future studies on this aspect will allow us to further understand students' construction of learning communities in science classrooms.

Finally, there could be other influences of the Korean classroom context on student agency and the way the students conflicted with each other in subsequent discussions. However, since this study analyzed students' interactions on a micro scale and described the dynamics of focused student interactions, the influence of more macro-scale social structure on students' interactions was not thoroughly discussed. Future studies can address this issue to understand and support student agency and collaborative discussion in argumentation activity specifically in Korean science classrooms.

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Appendix

Appendix 1. Contents of the argumentation activities implemented in the science classrooms

	Topic of the activity	Specific activities
1	Introduction to argumentation	Introduction to argumentation activity and the structure of argument
2	Establishing rules for small-group activity	Establishing rules for small-group activity
3	Function of roots	Arguing for the function of roots: supporting the plant versus absorbing the water
4	Osmosis (carrot's absorption of water)	Watch how sugar inside the carrot disappears when the carrot is soaked in water. Construct an explanation for the phenomenon.
5	Transportation of water through xylem	Develop arguments about what color the leaves are, when the stem of a lily is divided in half and the halves are soaked in red- and blue-pigmented water, respectively.
6	Observation of the leaf tissue	Observe a microscopic photograph of a leaf and the structure of a leaf tissue, and argue which side of the leaf in the photograph is the upper side.
7	Transpiration	Predict whether a plant with petrolatum jelly on the leaves or a plant without petrolatum jelly will grow better
8	Reactants of photosynthesis	Design an experiment to verify that carbon dioxide is used for photosynthesis.
9	Light intensity and photosynthesis	Critically evaluate two interpretations of the results of an experiment about photosynthesis and light intensity, and choose a more persuasive argument
10	Cellular respiration of beans	Develop arguments about whether a germinated bean or a non-germinated bean is heavier.
11	Girdling	Observe a photograph that shows a tree that has been peeled so that the top part has bulged, and develop an argument to explain this phenomenon.

국문 초록

중학교 과학 수업의 소집단 논변활동에서 협력적 기여자로의 전환 시에 나타난 학생들의 행위주체성 탐색

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과학적 논변활동은 과학자 공동체가 지식을 구성하는 과정의 사회적 측면이 반영된 활동으로서 과학 교육에서 조명 받고 있다. 그리고 과학 교실 속 논변활동에서 학생들이 지식 구성의 주체로 자리할 수 있도록 지원하기 위해서는 논변활동의 도입과 더불어 교사만이 “과학적” 지식을 지닌다는 인식으로부터 벗어나도록 지원해줄 필요가 있음이 주장되고 있다. 이러한 주장 하에 선행 문헌에서는 학생들의 생산적 프레이밍을 촉진할 수 있는 교수학습 맥락이 탐색되어왔다. 즉, 학생들이 과학 교실 속 논변활동을 그들이 지식 구성의 기여자로서 참여할 것으로 기대되며 그러한 권한이 주어진 활동이라고 프레이밍할 수 있도록 촉진하는 교수학습 맥락이 탐색되어 왔다.

하지만 이러한 맥락에서 학생들이 어떻게 자신뿐만 아니라 서로를 지식 구성의 기여자로 인정하게 되는지에 관해서는 잘 논의되지 않았다. 본 연구는 학생들이 과학 교실 속 논변활동에서 협력적 기여자로 자리해가는 과정을 촉진하는 중요한 요인으로서 학생의 행위주체성에 주목하였다. 이를 보이고자 다음과 같은 연구들이 이루어졌다. 먼저 프레이밍의 전환 과정에서 학생의 행위주체성을 포착할 수 있는 접근 방법을 고안하고자, 학생의 행위주체성에 관한 이론적 고찰 연구를 진행하였다. 그 다음 이 연구에서 고안한 접근 방법을 바탕으로 두 사례 연구가 진행되었다. 첫 번째 사례 연구에서는 학생들이 서로를 협력적 기여자로 프레이밍하게 된 소집단에 주목하였으며, 이러한 프레이밍 전환이 일어난 그들의 논의 과정을 탐색했다. 연구 결과에서는 학생의 행위주체성이 이러한 프레이밍의 조율과 전환 과정을 촉진한 주요 요인임을 보여주었다. 두 번째 사례 연구에서는 프레이밍의 조율을 촉진하는 행위주체의 담화 실행과 그에 이은 학생들의 논의에서 어떻게

프레이밍이 조율되는지 탐색하고자 하였다. 이에 학생들 간의 프레이밍 차이와 조율 과정이 명료히 드러나는 사례를 탐색하고자 다른 학생들과의 상호작용에서 소외된 학생의 사례에 주목하였다. 분석 결과는 과학 교실 속 논변활동에서 협력적 학습 공동체의 형성에 학생의 행위주체성이 어떠한 역할을 하는지에 관하여 깊이 있게 보여주었다.

구체적으로 학생의 행위주체성에 관한 이론적 고찰에서는 선행 문헌에서 행위주체성의 어떠한 측면을 다루었으며 학습 공동체를 구성하는 행위주체로서 학생들의 실행을 어떻게 탐색해왔는지 검토하였다. 분석 결과는 선행 문헌에서 행위주체성이 인식적 행위주체성, 변화적 행위주체성, 실천적 행위주체성, 학문의 행위주체성, 물질의 행위주체성으로 크게 다섯 가지 측면에서 논의되었다는 점을 보였다. 그리고 학습 공동체를 구성하는 행위주체로서의 학생들의 실행을 분석하는 방법은 '학습 공동체 전반의 행위주체성에 주목한 경우', '초점을 맞춘 한 학생이 공동체의 활동 구조에 미치는 영향에 주목한 경우', '여러 학생들 사이의 상호작용에 주목한 경우'로 구분되었다. 이러한 분석 결과를 바탕으로, 소집단 학생들의 프레이밍 전환을 촉진하는 학생의 행위주체성에 대한 접근 방법을 고안하였다.

고안된 틀을 바탕으로 두 사례 연구가 이루어졌다. 두 연구에서 모두 학생이 협력적으로 지식을 구성하는 과정으로서 논변 활동을 프레이밍할 수 있도록 설계된 논변 활동이 도입된 중학교 과학 교실을 탐색했다. 첫 번째 사례 연구에서는 학생들이 서로를 협력적 기여자로 프레이밍하게 되었음이 담화로부터 명확히 드러나는 소집단에 주목했다. 그리고 이 소집단의 학생들이 어떻게 그들의 위치에 관한 프레이밍을 조율해갔으며, 이 조율 과정은 어떻게 촉진되었는지 탐색했다. 초반에 이 소집단의 상호작용은 학생들이 모두 상호작용에 참여하고 있었으나 그 상호작용은 인식적 권위가 높은 학생에게 집중된 양상을 띠고 있었다. 한 학생이 인식적 권위가 높은 학생으로부터 벗어난 상호작용 영역을 형성하면서 이 상호작용 양상이 변화하기 시작했다. 이 학생은 학생들이 서로를 협력적 기여자로 프레이밍하게 되는 조율 과정을 촉진하였고, 이는 소집단 구성원 모두가 추론을 정교화해가며 공동의 지식 형성에 기여하는 논의로의 전환으로 이어졌다. 이러한 분석 결과는 선행 문헌에서 학생들의 생산적 프레이밍을 촉진하였다고 논한 맥락이 더 정확히는 학생들이 프레이밍 조율하는 과정을 촉발한 맥락인 것임을 보였다. 그리고 학생의 행위주체성이 소집단 학생들이 구성원들을 협력적 기여자로 프레이밍하도록 촉진하는 과정에 중요한 역할을 함을 보였다.

두 번째 사례 연구에서는 다른 학생들에게 기여자로 인정받지 못하고 소외된 학생이 있는 소집단에 주목했다. 그리고 이 소외된 학생이

소집단 논변활동에의 협력적 기여자로 자리하고자 시도하면서 나타난 행위주체로서의 발화 유형을 드러내었다. 또한 각 유형의 발화에 뒤이은 학생들의 상호작용에서 소집단 활동의 구조가 어떻게 조율되었는지 탐색했다. 논의에서는 과학 교실 속 논변활동이라는 맥락이 학생들이 활동 구조를 조율해가는 과정에 어떠한 영향을 미쳤는지 다루었다. 소외된 학생의 발화 유형은 “추론의 제시”, “인식론적 프레이밍의 제시”, “이전 인식적 실행에 대한 검토 의견 제시”로 구분되었다. 각 유형의 발화 뒤에 이어진 학생들의 논의는 소외된 학생에 대한 학생들의 프레이밍과 권력 관계에 따라 다양하게 나타났다. 대부분의 경우, 이 논의는 소외된 학생이 소집단의 공동 지식 구성 과정에 기여할 수 있는 인식론적 프레이밍이나 자원을 가지지 못했다고 여기는 다른 학생들의 인식을 드러내었다. 하지만 소외된 학생의 의견이 논의에서 다뤄지는 경우도 있었다. 이는 크게 세 가지 양상으로 나타났다. 첫 번째는 그의 의견에 대한 반박이 먼저 선행된 후에 논의가 이루어지는 경우였다. 두 번째는 그가 자신의 의견이 타당함을 교사의 안내나 과학적 논변활동의 특성을 기반으로 정당화한 경우였다. 세 번째는 그가 다른 학생들에게 그의 의견을 보충시켜주길 요청한 경우로, 이때 그의 의견이 다른 학생들에 의해 수정될 수 있는 여지를 보였다. 소외된 학생의 실행과 추론은 과학적 개념과 일치하거나 과학적 논변활동의 특성을 반영한다고 정당화될 때 그 타당성을 인정받는 모습을 보였다. 이 과정에서 학생들은 지식 구성자로서 위치하면서도 과학적 논변활동의 대화적 측면이 반영된 활동 구조를 형성해가는 양상을 보였다.

이러한 연구 결과를 바탕으로 본 연구는 과학 교실 속 소집단 논변활동에서 학생의 행위주체성이 학생들이 서로를 협력적 기여자로 프레임하는 과정에 학생의 행위주체성이 중요한 역할을 함을 보이고, 학생들이 어떻게 그와 같이 자리해가는지 탐색하였다. 이로부터 학생들이 대화적 논변활동에 참여하도록 촉진하기 위해서는 학생들의 프레이밍 전환을 촉진하는 교수 맥락을 조성하는 것에서 나아가 서로를 협력적 기여자로 여기는 프레이밍을 공유하고자 하는 학생의 행위주체성 발휘를 지원하는 것이 중요함을 알 수 있다. 본 연구는 학생들의 협력적인 학습 공동체 구성 과정을 지원하기 위한 노력에 깊이 있는 이해를 제공해준다는 점에서 그 의의를 지닌다.

주요어 : 행위주체성, 프레이밍, 위치짓기, 논변활동, 협력적 기여자, 프레이밍 조율 과정

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